90-06822/

International Union of Forest Research Organizations

Union internationale des instituts de recherches forestières

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Unión Internacional de Organizaciones de Investigación Forestal

XIX World Congress

XIX Congrès mondial

XIX. Weltkongreß

XIX Congresò Mundial

Montréal, Canada

5-11/8/1990

Published by the Canadian IUFRO World Congress Organizing Committee.

Publié par le Comité canadien d'organisation du Congrès mondial
de l'IUFRO.

Herausgegeben vom kanadischen Organisationskomitee
des XIX. IUFRO-Weltkongresses.

Publicado por el Comité Organizador Canadiense del Congreso Mundial
de IUFRO.

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Invited Papers
Communications sollicitées
Ausgewählte Beiträge
Ponencias solicitadas formalmente

MODELING THE STRUCTURE OF PRECOMMERCIALLY THINNED PINE STANDS

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FDC: 568: 241: 174.7 *Pinus elliottii* Engelm.--01

Data from studies on the effects of early thinning in dense, young direct-seeded slash pine (*Pinus elliottii* Englm.) stands were used to develop prediction models that describe the effects of several alternative thinning practices on stand structure over time. The thinning methods utilized were: (1) strip thinning with various strip widths (including a checkerboard pattern), (2) combination strip and selective thinning (including a deferred selective thinning following the strip thinning), (3) selective thinning to various density levels, and (4) no thinning. All stands were 3-4 years old at the time of thinning with before-thinning densities averaging about 12,000 trees per hectare. After-thin densities ranged from about 1200 to 10,000 trees per hectare. Systems of equations were developed to predict diameter distribution moments and means, and to subsequently estimate diameter distribution parameters, as functions of stand age, site index, and numbers of surviving trees. It is shown that separate systems of equations are required for strip-thinned and selectively-thinned stands because of the different diameter distributions that are produced by these alternate density reduction procedures. This paper presents the modeling methodology and statistical analyses utilized, and average stand structures produced, up to age 25, by the various precommercial thinning techniques.

A COMPREHENSIVE CONCEPT OF TREE AND STAND MEASUREMENTS

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FDC: 524.63: 524.14

ABSTRACT

The future questions will not be "Permanent plots versus point sampling", or "Why and how critical height sampling ?", or "What advantages will Zöhrer's suggestions about sampling with programmed probabilities bring, and how to perform them ?", or even the point sampling methods by Hirata and Minowa using vertical angles. All these items are not real "problems" for measurement techniques in the forests, but can be answered by computers alone if we use a comprehensive concept for point sampling, shortly outlined in this article. The basic feature of it is to develop a special science and technology for getting perfectly adapted taper functions for every sample tree in question. More than ever before, the Tele-Relaskop and the Spiegel-Relaskop (Wide Scale or CP-Scale) with the new micro attachment can be used for the development of taper functions as well as for controlling them occasionally and/or permanently. These two instruments now available can be described as the "corners" for future developments which will allow any enlargement between zero and 8-times. An optimally seeming technique for measuring trees and stands is recommended in this paper.

PROJECTING STAND AND STOCK TABLES: A COMPARISON OF THREE METHODS

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FDC: 567: 228.5--015.5

Often, it is desired to project an existing stand and stock table to a future age in even-aged stands. There are several alternative procedures available to modelers to accomplish this goal. Below, I compare and contrast three such procedures for projecting stand and stock tables for loblolly pine (Pinus taeda L.) plantations grown in the southeastern United States. One procedure is a Weibull parameter recovery model, another is a distribution free percentile-based algorithm, and the third uses an individual tree distance independent basal area projection model.

Each projection procedure was fitted to a large loblolly pine data base. Statistics of fit for the fitted data base and an independent data base were generated for number of trees by diameter class, volume by diameter class, and volume by product class. The procedure based on the individual tree distance independent basal area projection model was superior to the other two modeling procedures for most of the fit statistics.

VEGETATION-BASED CLASSIFICATIONS: HOW MUCH OF THE VARIATION IN BASAL AREA PRODUCTION DO THEY EXPLAIN?

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FDC: 561.25: 542: 541

The difficulty in quantifying the moisture, nutrients, and energy available to plants growing in a natural environment has been a driving force behind the development of vegetation-based site classification systems. These systems attempt to use vegetation to identify areas of the landscape with similar growing conditions. If areas with similar environments are identified, then there should be less variation in forest overstory growth among these areas than between areas with different environments. Unfortunately confounding factors such as different overstory properties, human disturbance, and temporal variation in environmental inputs also influence growth and have made it difficult to test this hypothesis. However, for 35 permanent plots in northern Minnesota established to study the effect of cutting methods and growing stock levels on red pine growth, many of the confounding factors are controlled. We will compare how much of the variation in basal area production over a 25-year period (ranging from .31 to .53 m^2 ha^{-1} yr^{-1}) of a nearly pure red pine overstory is explained by one mensurational (site index) and three ecological (synecological coordinates, divisive classification, and ordination) approaches to vegetation-based classifications.

PROFILE AND THICKNESS DISTRIBUTION OF BRANCH AND ROOT BIOMASS AS SPECIFIC CHARACTERISTICS OF FOREST BIOLOGICAL PRODUCTIVITY

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R.R.Sharafutdinov

Urals Forest Engineering Institute, Sverdlovsk, USSR

FDC: 568

The studying of forest production structure usually connected with application of vertical distribution of branch and root biomass or thickness distribution for whole tree. The authors have proposed profile and thickness distributions of the same indices of pine and spruce stands of the Middle Urals in the form of bivariate integral curves - cumulates. Relationships between biomass fractions cumulative values (P,kg) and their diameters at butt end (d,cm) are presented as: $P=f(d)$ (1). These relationships change along the vertical profile of the above- and underground tree parts, i.e. they may be supplement by variable h - relative distance from ground level, as: $P = f(d,h)$ (2). These bivariate cumulates (2) in one´s turn are modified with breast height diameter (D,cm) and tree age (A,yr) and the total equations form is $P = f(d,h,A,D)$ (3). Equations (3) are tabulated. This resulted in the tables with 4 inputs for cumulative biomass values, that are transformed by successive values subtraction. Every cell of the table is characterized by its own biomass value, and its corresponding fraction having other specific properties, such as: intensity of destruction and of drawing in mineral cycling, chemical composition, physical and mechanical properties, combustibility, timber consumer cost etc.

Analytical expressions (3) may be jointed with dynamic models, such as: computer simulation model of tree and stand growth, nutrient elements and energy cycling model, forest fire model, model of recreational and protective forest functions etc. Equations (3) give also a possibility to compare biological productivity potentials of forest phytocenosis in different forest types.

GROWTH AND YIELD PREDICTORS FOR NATURALLY-REGENERATED EVEN-AGED SOUTHERN PINE STANDS - RECENT RESULTS AND FUTURE RESEARCH PROSPECTS

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Mississippi State, MS, and Monticello, AR, USA

FDC: 564: 228.8: 228.5--01

Research to develop growth and yield information for managed natural stands of southern pine has led to significant innovations in prediction technology. Past efforts, products, and lessons learned are briefly reviewed. The features and utility of current prediction systems, both developed and developing, are discussed along with the status of ongoing supporting research. A newly-developed dual stand-level/dbh-distribution prediction system and a developing companion individual-tree predictor for thinned and unthinned longleaf pine stands are examined in detail. An analysis of future research needs, including database establishment and maintenance and supporting research, is also discussed.

SIMULATING BRANCH DIAMETER AND BRANCH DISTRIBUTION IN YOUNG DOUGLAS-FIR

Maguire. D.A., Moeur, M., an[illegible]ennett, W.S; University of Wasnington.

FDC: 568: 815.31: 174.7 Pseudotsuga menziesii Franco

Branching pattern and branch dynamics relate closely to the ecophysiological processes of growth in young plantations, and influence strongly the quality of wood recovered from the butt log of the final crop trees. A system of equations was constructed to simulate the number, diameter, and distribution of primary branches along the stem of young Douglas-fir trees prior to crown closure. Three to ten annual shoots from the main stem of 189 Douglas-fir trees were the basic modeling unit. Within each annual shoot, relative diameter was expressed as a function of relative height. Maximum diameter, which virtually always occurred on one of the nodal branches, was predicted primarily from depth into crown. The number of branches per length of annual shoot was modeled as a function of relative tree size and growth rate, and the relative vertical distribution of branches within each annual shoot was assumed constant among shoots, trees, and sites. Simulated branch diameter arid branch distribution on 18 trees from a validation data set suggested the general efficacy of this approach, as well as areas needing further work.

PARAMETER FREE DIAMETER DISTRIBUTION RECOVERY

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FDC : 568: 242--015.5

Constrained least squares and linear programming methods are discussed and illustrated for allocating mortality, thinning removals, and diameter growth to tree diameter list. In the procedure, allocation functions are derived to recover arithmetic and quadratic mean diameter on the thinned stand, projected stand or residual stand at time 0 after mortality trees are removed. Because the procedure operates from a tree diameter list, instead of assuming a parametric probability model it provides a highly flexible framework in which to model stands having diameter distributions poorly approximated by probability functions.

PERSONAL KNOWLEDGE AS PRIOR INFORMATION IN VOLUME ESTIMATES

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FDC: 524.39

Personal knowledge is used as prior information in a Bayesian estimate of volume per hectare. The prior information is represented as a Beta distribution from the manager's opinion of the minimum, maximum, and most probable volume per hectare. A posterior distribution is developed from the Beta prior and sample data. The mean and confidence interval are calculated from the posterior distribution. No additional field work is required. The calculations can be performed on a spread sheet program.

The range of probable volume has the most influence on the final volume estimate. When the minimum and maximum are nearly the same as their sample data counterparts, the prior distribution has little effect. A very narrow range centered near the sample data mean can reduce final confidence interval width by 40%.

However, gain can be measured in ways other than reduced confidence interval width. Using personal knowledge gives a manager the opportunity to influence volume estimates. He or she need not accept uncritically the one-time measurement the field data represents.

BIRCH STAND SIMULATION WITH DIRECT ACCOUNT OF CROWN COMPETITION

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Leningrad, U.S.S.R.

FDC: 564: 181.21: 176.1 Betula pendula Roth.--01

This model can be classified as single tree, distance dependent. Its main distinctions from models of the same type are: 1) direct account of light regime of a crown instead of competition indices; 2) account of crown's horizontal displacement due to expansion in the direction of more open space. Crown competition is considered to be dominant in birch (Betula pendula) stands growing on fertiles soil with sufficient moisture. The existence of a number of specific characteristics is postulated where age- and site-dependent values determine the development of each tree in a stand. For this version of the model these characteristics are: 1) potential height growth; 2) potential crowns radial growth; 3) average crowns transparency; 4) critical PhAR value at a crown's top, which determines vitality of a tree; 5) critical PhAR value at a crown's base, which determines lowest branch vitality; 6) form coefficient of a bole. Calculations of light regime at arbitrary canopy points are based on preliminary data from June-August total PhAR sums angular distribution. The results of verification, mainly against growth table data for birch stands, are quite satisfactory. The model provides an explanation for some peculiarities of stand and canopy development in birch. It represents the dynamics of thinned stands and could be used for analysis of birch and birch-spruce stand management alternatives; the model should also prove useul for student training at forestry colleges.

A simple and useful tree attribute for stem-form: Height to two-third breast-height diameter

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FDC: 524.11

ABSTRACT

A measure of stem form is presented for accurate estimation of volume and for predicting upperstem diameters. Rustagi and Loveless (1989) have shown that $R_{.67D}$ (the ratio of height to two-third breast height diameter $H_{.67D}$, and the total tree height H) provides a simple but effective measure of the upper-stem form factor with substantial reduction in the residual mean square. As bark thickness at breast height tends to be stand specific, it is proposed to use inside bark (instead of outside bark) diameter in the volume prediction models. Explicit use of stem-form attribute, and stand based inside bark prediction models should minimize (if not eliminate) volume prediction bias when volume tables are used in specific stands. It should also provide a better alternative to the Tarif system which makes very rigid assumptions about tree height distribution and stem form.

$R_{.67D}$ is not only useful in predicting volume or in the prediction of upper stem diameters, it is likely to play an important role in: a) the assessment of inter-tree competitive stress and, therefore, in growth models; b) in proper assessment of the response to silvicultural treatments on growth; and c) in the prediction of suppression mortality. These aspects are currently under investigation.

Rustagi, K.P. & R. Loveless, 1989: A variable form volume and taper model for Douglas fir. Manuscript submitted to the Canadian Journal of Forest Resources.

GROWTH, YIELD AND TIMBER DENSITY OF SHORT ROTATION COPPICE STANDS OF *EUCALYPTUS GRANDIS*

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FDC: 56: 238: 176.1 Eucalyptus grandis: (680)

SUMMARY

The effects of timing initial coppice reductions, number of reductions and final number of shoots per stool on growth and yield of *Eucalyptus grandis* are described. The basic data were obtained from three experiments situated in different climatic zones of the summer rainfall area of South Africa. The influence of the site differences, stocking densities, mortality and factorial treatments on timber yield and timber density are compared at harvesting at about ten years of age. The relationships of yield and timber density of the parent seedling crops and those of the coppice crops are compared and the influence of different growth rates due to prevailing climate and management are analysed. The importance of basal area as a predictor variable of yield at harvesting for the wide range of treatment interactions are stressed. On the basis of these results and observations in commercial plantations, practical recommendations are given for the management of *E.grandis* plantations grown from coppice with different management objectives.

TREE AND STAND VOLUME EQUATIONS FOR *EUCALYPTUS GRANDIS* PLANTATIONS IN WESTERN KENYA

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FDC: 524: 176.1 *Eucalyptus grandis*

Tree and stand volume equations are developed for *Eucalyptus grandis* plantations in Western Kenya. Total tree volume, merchantable volume to a variable top diameter limit, and taper functions are developed using the logarithmic model. Separate equations are necessary for coppiced and non-coppiced plantations. A single equation is developed which predicts total per hectare yield and per hectare yield to any merchantable top diameter limit. A set of anamorphic site index equations and a stand basal area growth curve are developed. The system of equations indicates that mean annual increment culminates at approximately five years across the range of site indices present in these plantations.

FRACTAL ANALYSIS OF CROWN STRUCTURE

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FDC: 531/533: 181.21--015.5

Because tree crowns collect solar energy collectors and exchange gases, their structure is closely related to tree productivity. Adequate methods for the description of complicated objects such as tree crowns have been proposed only recently by fractal geometry. Besides the standard box-counting method, a number of workable methods for determining fractal dimensions of crowns have been described. Crown structure can be characterized by more than one dimension. In addition to dimensions describing foliage distribution, there are the spectral fractal dimensions which describe a system's connectivity and branching properties.

The reported studies show that crown fractal dimension is a good indicator of species tolerance. Still, tolerance (or rather self-tolerance) alone is not a sufficient explanation of the value of the dimension. Deep penetrating cavities in the crown would let the sunlight in and would result in a substantial density of foliage inside the crown of even intolerant species. Thus, the same high crown dimension could be achieved by physiological adaptation (such as a wide range of foliage sensitivity to radiation) and by structural adaptation (such as a pervious crown). Accordingly, we can introduce the concepts of functional depth and structural depth of the crown. It is functionally deep when foliage is present inside the crown because of the ability to function in low light intensity. Functional depth is an indication of self-tolerance of foliage. Structural depth results from self-avoidance of foliage.

A notion of the field of crown depth was introduced in order to visualize measurement of the functional and structural crown depths. The field is bounded laterally by the extreme fractal values of natural surfaces (two and three) and by lower and upper values of foliage mass. The measures of the depths are based on the comparison of the actual and maximal intervals between the points representing tree species and the corners of the field representing extreme cases of crown depth.

FITTING THE WEIBULL FUNCTION TO DIAMETER DISTRIBUTIONS OF TROPICAL TREE SPECIES AND FORESTS

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FDC: 568--015.5

The weibull function was fitted to diameter data of 60 tropical forest tree species from State of Maranhao, Brazil. It was the following methods of parameter estimation: maximum likelihood, percentile, moments and linear function methods. All methods produced distributions not statistically different from observed ones, except the linear function method. The maximum likelihood estimates had the lowest variance, but observed distribution were better represented by percentile method. The number and width of diameter classes influenced the percentile estimates, when percentile were obtained from grouped data. RAMSDELL, an algorithm suggested by Ramsdell, is an adequated way to choose number and width of diameter classes.

The weibull function was also fitted to diameter distributions of 88 inventory plots, using percentile method. From these plots only 19 plots showed estimates of weibull shape parameter (c) statistically different (5% probability level) from 1. So, the De Liocourt Law, as a representation of exponencial distribution which is a particular case of weibull function when c=1, can be assumed from most of the plots.

Most of the tree species studies, however, had an estimate of shape parameter different from 1. This indicates that although De Liocourt can be applied to the whole tropical forest, it is not true for all individual tree species present in the forest. The weibull shape and scale parameter estimates for tropical tree species can vary according to ecological groups like: pioneers, gap opportunists and climaces.

CHANGES IN GROWTH AND YIELD MODELLING IN RESPONSE TO SOCIAL AND ENVIRONMENTAL CHANGE

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SUMMARY

Growth and yield prediction in forestry has traditionally used the experience-based, "historical bioassay" approach. As both local and global environmental conditions continue to be changed by human activities, and as population growth, market forces, and changing public attitudes towards forestry force changes in management practices, our experience of past growth will have decreasing relevance for the future, and will provide a less reliable basis for future growth predictions. This will require the use of an increasing component of knowledge-based simulation in growth and yield models. However, knowledge-based prediction, in the form of process-based simulation models, on its own is not expected to replace experience-based prediction in the near future because of continuing limitations on our knowledge, and because of the calibration data requirements of this approach. However, it is anticipated that there will be increasing use of hybrids between experience-based and knowledge-based approaches. These hybrid simulation models will either vary greatly in their complexity according to the particular management and environmental futures for which growth and yield predictions are required, or they will be flexible modelling frameworks which can be used at various different levels of complexity. Such hybrid models might be as simple as a simulation of nutrient limitation added to a historical bioassay model (eg. FORCYTE-10), or as complex as a nutrient, light and moisture-limitation ecosystem model with climate change, "acid rain", alternative silvicultural systems, and "old-growth" simulation capabilities (eg. FORECAST; in development). The design of the type of hybrid growth and yield model that it is thought will be needed in the future is described, and some suggestions are made concerning how such a model could be used in public and high school eduction as well as in the role of a professional decision-support tool and a flexible growth and yield predictor.

INTRODUCTION

Few renewable resource managers are obliged to plan and predict over such long temporal and large spatial scales as foresters in the northern temperate and boreal regions. The magnitude of these scales confers on forestry at these latitudes a variety of special problems. By the time tree crops planted in these areas in 1990 are ready for final harvest, the present world population is expected to have doubled, and the global climate is expected to have changed substantially. Increasing competition for the land base, and changing public attitudes about forested landscapes are expected to result in a reduction in timber-producing forest land area in many parts of the world. This will occur at a time when there is an increased demand for forest products and a renewed interest in forests as a renewable source of bioenergy.

Changes in the political, social, economic, and environmental conditions that affect forests and forestry have occurred for millennia, but never at the present rate, nor on the present global scale, both of which are challenging many of the traditional institutions and assumptions of forestry. Sustainable annual allowable cut calculations are problematical in areas where environmental groups are repeatedly demanding the reservation of new old-growth, wilderness and recreation areas. The selection of the species and initial stocking density to be established in plantations are difficult in the face of climate change predictions. And traditional growth and yield prediction methods are becoming increasingly questionable in the face of climate change, air pollution ("acid rain" and other related effects), and the soil changes that accompany shorter rotations, whole tree harvesting, and increased mechanization. When these types of change were occurring more slowly, foresters could simply adjust their planning and prediction methods as change occurred. But the rate of change is now so great relative to the time taken to produce tree crops that changes in traditional planning and prediction methods are not able to keep up. We are facing a form of "future shock" in forestry.

The objective of this paper is to examine the implications of rapid social and environmental change for the way growth and yield are predicted, and thus how annual allowable cuts are calculated. The shortcomings of traditional growth and yield prediction methods in the face of such rapid changes are examined, and a more flexible approach is suggested. Some of the ideas have been presented elsewhere and will therefore not be explored in detail (eg. Kimmins 1985, 1986, 1988, 1990a, 1990b; Kimmins and Sollins 1989). Referencing of the sources of information and ideas presented here may be found in these papers. Space limits detailed referencing in this paper.

THE CHALLENGE OF CHANGE FOR TRADITIONAL GROWTH AND YIELD PREDICTION MODELS

The traditional method of predicting future growth and yield of long-lived forest crops is to extrapolate the record of past growth into the future: the so-called "historical bioassay" approach. Most modern mensurational growth and yield models are simply an elegant elaboration of the basic historical bioassay: the yield table. Indices that describe the historical patterns of biomass accumulation, allocation, and stand dynamics are derived from historical data sets on how a population of a tree species (or a mixture of species) has grown in the past, and these indices are used to project how populations of that species (or mixtures) will grow in the future. As long as the future silvicultural systems and environmental conditions (soil, climate, and biotic) remain similar to those of the past, it is difficult to imagine a better system. It is not limited by our still incomplete understanding of the functioning of forest ecosystems over rotation-length time scales, nor by limitations on our ability to rectify knowledge gaps. However, the method is inflexible in that it cannot predict growth and yield for futures about which we do not yet have any experience: futures for which we do not yet have a historical bioassay. This inflexibility of the traditional yield prediction method in the face of significant environmental change was investigated and reported as early as the middle of the last century.

One of the major challenges in growth and yield modelling in the 1990's will therefore be either: 1, to develop flexible alternative yield prediction approaches that are not experience based (ie. knowledge-based prediction systems), or 2, to modify the traditional historical bioassay experience-based approach to give it the degree of flexibility required to predict yield for specific future management and environmental regimes. A second challenge will be to expand growth and yield modelling from the prediction of harvestable stemwood to the prediction of temporal patterns of total tree biomass accumulation (by biomass component), of the biomass of non-crop vegetation, of the interactions between crop and non-crop vegetation, and of various wildlife habitat values. The public no longer accepts the view of forests as a biological factory of dimensional lumber and industrial fibre, and our growth and yield predictors must reflect this changing social and political climate. A third challenge will be to develop growth and yield simulators that can examine the sustainability of yield over at least three rotations. Sustained yield has always been the cornerstone of professional forest management, though foresters have rarely used planning tools that could truly address this issue. However, the public is now demanding "proof" that forest resources are being managed in a sustainable manner. This requires that we use planning and prediction tools that are sensitive to this question.

In short, the challenge is to develop and use predictors of ecosystem structure, function, and dynamics which can represent the consequences of a wide variety of possible future stand-level management scenarios and environmental conditions (climate, soil, fire, biotic agents).

ALTERNATIVE APPROACHES TO GROWTH AND YIELD MODELLING FOR THE 21st CENTURY

One possible alternative to purely experience-based prediction is to use purely knowledge-based prediction. With the dramatic increase in our knowledge of the ecology and physiology of tree growth and stand development, it is now possible to develop complex, process-based computer simulation models of forest growth and yield. However, the technical and knowledge-base requirements of this approach are formidable, and it seems probable that purely process-based simulation models will not replace traditional historical bioassay models in the 1990's. They will remain as important research and teaching tools for at least the next decade, but there is little reason to suppose that useable process-based simulation growth and yield models will not be available and an approach of choice sometime early in the next century.

For the next decade or until practical process-based simulation models are available, the optimum strategy would appear to be to employ a hybrid approach in which some process-based simulation is added to historical bioassay models. The extent of such additions will be determined by the questions such models will be asked to address. I envisage either a wide range of models that vary in complexity, or a smaller number of highly flexible models that can be used at various levels of complexity. The former option would involve models ranging from a simple historical bioassay model with the addition of a simulation of a single limiting factor (eg. nutrients), to a complex historical bioassay model with simulations of a wide range of potentially limiting factors. For the latter option, I envisage a flexible modelling framework within which the user has the option to structure the model at the level of complexity that is appropriate for some specific prediction application. This is the approach taken in FORCYTE-11 (Kimmins 1988, 1990; Kimmins and Sollins 1990; Kimmins et al. 1990).

DESIGN CRITERIA FOR A HYBRID SIMULATION GROWTH AND YIELD MODELLING FRAMEWORK

As suggested above, increasing pressure from alternative land users and the public is going to require the development and use of growth and yield prediction tools that can address questions of resource sustainability and multiple-use of the forest. These models must have the flexibility to simulate the probable multiple-rotation consequences of various combinations of: a wide variety of stand-level silvicultural treatments, untested alternative silvicultural systems, natural disturbance events, global climate change, regional changes in atmospheric chemistry (eg. "acid rain"), and management for wildlife and various "old-growth" values. The models should be able to predict total biomass production, total harvestable biomass by individual biomass components, economic yield at various utilization levels, sustainability of production and yield, wildlife carrying capacity for various key species, the economics of stand production, the carbon budget of stand management (with reference to the "greenhouse effect"), and the energy-efficiency (fossil fuel input requirements vs stored solar energy in harvested biomass) of management.

It is widely felt that it can be a mistake to build mega-models that try to be all things to all people. The problems of model size, complexity, input data requirements, computer hardware requirements, and equally difficult problems of model verification and validation have convinced many modellers that it is better to develop a series of simpler models with more limited objectives. There is certainly logic and support for this position, but it misses one key point: that in forestry we are managing entire ecosystems, entire forested landscapes in which the temporal changes in any one component of the landscape is very much dependent on the other interacting components. This has been the power of Geographic Information Systems: the ability to represent much of the horizontal spatial complexity of resource values so that computers can address real life questions that have a strong spatial component. It is time to apply the same philosophy in stand-level growth and yield modelling: to represent much more of the structural and functional, complexity of the forest ecosystem so that we can make believable predictions for a variety of ecosystem values for a variety of possible futures.

How then can we deal with the complexity of future growth and yield modelling in a manageable way? One solution, which has been used in the FORCYTE (FORest nutrient Cycling and Yield Trend Evaluator) series of models, and is being implemented in a new model FORECAST (FORestry and Environmental Change ASsessmenT), is to develop the model as a modelling framework, with a series of independent programs, linked by transfer files. The approach involves a series of plant growth modules and a soil process module which accept input data that define historical patterns of plant biomass accumulation and turnover, and data that define a variety of processes that the user might wish to represent as potentially limiting factors in the hybrid simulation ecosystem-management program. These preliminary or "setup" programs prepare a series of indices of canopy function, growth allocation, intra-specific competition, site biogeochemistry, etc. These indices are then passed on to the main program where they are used to drive a simulation which in essence asks the question: "Given the simulation of future changes in various growth-determining factors and processes, will the historical patterns of biomass accumulation and stand development reoccur in the future?" Because of the potential complexity of the output, analysis of the predictions of this main program is undertaken in a separate, third, modelling activity for which specific software has been developed.

The type of modelling framework that is employed in both FORCYTE-11 and FORECAST provides the model user with the choice as to what level of ecosystem complexity and what type of futures can be represented. The models can be run as historical bioassay models of a single tree species, although they do represent far more detail (eg. estimates of different biomass components, and of forest floor mass) than traditional mensurational models. Alternatively, they can be run as multi-tree species, multi-life form models with a simulation of site biogeochemistry, competition for, and growth effects of, the availability of nutrients and light. FORECAST has a variety of capabilities that FORCYTE-11 does not have, including temperature and moisture as growth determinants (giving FORECAST the ability to simulate the effects of climate change), and several additional management and natural disturbance options. Planned future additions to FORECAST include representations of some "acid rain" and air pollution effects.

APPLICATION OF ECOSYSTEM-LEVEL GROWTH AND YIELD SIMULATION MODELS IN PROFESSIONAL, UNIVERSITY, HIGH SCHOOL, AND PUBLIC EDUCATION

Forestry will probably never be quite the same as it was before the report of the Brundtland Commission Report (World Commission on Environment and Development 1987). Although there is great confusion concerning the meaning and implications of "Sustainable Development", the message to foresters is clear: practise sustainable forestry and be able to show evidence that you are, or risk legislation or policy that reduces the industrial forest land base and how such lands may be managed.

Much improvement is needed in the quality of forest management in many parts of the world, but in many cases current forest practise is probably sustainable and environmentally sound. This message needs to be communicated to the public and politicians, together with a demonstration that foresters are using ecologically-sound tools by which to assess sustainability. The type of ecosystem-level growth and yield modelling framework described above lends itself to the development of colour-animation computer "games" by which to communicate the basic principles of sustainable silviculture to a range of audiences, from professional foresters, to high school students and concerned-citizen groups. In fact, just such a game (Sustainable Silviculture Simulator, using a program called FORTOON (FORest carTOON) is presently under development. This educational forest simulator will be driven by FORECAST. I believe that it is the responsibility of growth and yield modellers to assist in the development of these urgently-needed educational tools.

CONCLUSIONS

The days when it was acceptable to base annual allowable cut estimations on a simple forwards projection of past patterns of harvestable stemwood volume accumulation are gone. The public is demanding, and rightly so, that foresters demonstrate that they are sustaining the future production of timber and a variety of other important forest values and not just talking about it. Growth and yield modelling must respond to this demand by providing ecosystem-level stand management simulation models that can predict the growth, yield, economic performance, carbon budgets, wildlife values, and energy efficiency of alternative stand management strategies under a variety of possible future environmental conditions. Growth and yield modellers also have a responsibility to society to develop models that can be used to investigate the potential contribution of forest management to the "greenhouse effect"; models that can answer the question "is forestry part of the problem or part of the solution?"

Sustained yield at a regional level transcends individual stand considerations, but stand-level growth and yield models are nevertheless the foundation of long-term sustained development planning. Used in conjunction with GIS or other "whole-forest" models, ecosystem-level stand management simulators can contribute to the development of believable regional predictions.

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge a decade of financial and moral support from Forestry Canada (ENFOR program) without which the FORCYTE series of models would probably not have developed. Specifically, I would like to express my appreciation to Mike Apps, Lake Chatarpaul, and Jock Carlisle.

Other financial support and/or services for the research program that resulted in FORCYTE development, and for model development, was provided by Science Council of B.C., National Research Council of Canada, Ford Foundation, University of British Columbia, the B.C. Ministry of Forests, and various forestry companies.

Development of FORECAST and the Sustainable Silviculture Simulator is currently being funded by grants from the B.C. Ministry of Forests, the Council of Forest Industries of B.C., National Research Council of Canada, and several individual forest companies.

The contributions of numerous graduate students and support staff at the University of B.C. are gratefully acknowledged.

SOURCES OF BACKGROUND READING, AND OF REFERENCES TO THE MATERIAL PRESENTED IN THIS PAPER

Kimmins, J.P., 1985: Future shock in forest yield forecasting: The need for a new approach. Forestry Chronicle, vol. 61, pp. 503-513.

Kimmins, J.P., 1986: FORCYTE in forestry: The need for a systems approach in forest education, yield prediction and management. Pages 1-25 in: The E.B. Eddy Distinguished Lecture Series. Faculty of Forestry, Univ. of Toronto. Ontario.

Kimmins, J.P., 1988: Community organization: Methods of study and prediction of the productivity and yield of forest ecosystems. Canadian Journal of Botany, vol. 66, pp. 2654-2672.

Kimmins, J.P., 1990a: The scientific foundations for the simulation of ecosystem function and management in FORCYTE-11. ENFOR Project P-370, Final Report. Forestry Canada, Edmonton, Alberta.

Kimmins, J.P., 1990b: Modelling the sustainability of forest production and yield for a changing and uncertain future. Forestry Chronicle. In press.

Kimmins, J.P. and Sollins, P. 1990: Modelling long-term forest productivity. In: D.A. Perry et al. (Editors), Maintaining the Long-term Productivity of Pacific Northwest Forest Ecosystems. Timber Press, Portland, OR.

Kimmins, J.P., Scoullar, K.A. and Apps, M.J., 1990: FORCYTE-11 User's Manual. Forestry Canada, Edmonton, Alberta. In press.

World Commission on Environment and Development. 1987: Our Common Future. Oxford Univ. Press, 383 p.

EFFECTS OF AGE, SITE AND DENSITY ON THE DIAMETER DISTRIBUTION OF THE THINNED PRODUCTS FROM PINUS TAEDA PLANTATION IN THE STATE OF PARANA, BRAZIL

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FDC: 568: 242: 174.7 Pinus taeda L.

The objectives of this research were to study the diameter distribution of the thinned products and the possible effects of some factors on this distribution.

The data came from of hundreds of sample plots instaled in Pinus taeda plantations located in the State of Parana, covering the age range from 7 to 16 years old. The thinnings are normally carried out at ages 7 to 8, 11 to 12, 14 to 16 respectively for the first, second and third thinning. A relationship diameter breast height on stump diameter was developed to estimate the DBH.

It was used the "Maximum Likelihood Estimation for Selected Distributions MLESD" computer package to fit the diameter distributions. The tested distributions were: Normal, Log-Normal, Gama, Weibull, SB and Beta. These distribution were fitted through the Maximum Probability Method and the best one was selected by the criteria of Log Likelihood and Kolmogorov - Smirnov.

The Tuckey test was used for means comparison among the different treatments which were different ages, sites and density.

The Beta distribution was selected to estimate the number of thinned trees in relation to the diameter for the first and second thinning and the Log-Normal distribution was selected for the third thinning when the effect of the site was analysed. When the effect of age was analysed, the Beta function was selected for the first thinning, the Gama function for the second thinning, and the Log-Normal for the third thinning.

INTEGRATED SYSTEM FOR PRESENT AND FUTURE GROWTH AND YIELD PREDICTION AND ANALYSIS OF PINUS CARIBEA PLANTATIONS IN AGUDOS, SAO PAULO, BRAZIL

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FDC: 564: 242: 174.7 *Picea caribea* Morelet.

The objective of this research paper was to develop an integrated system to predict growth and yield for different commercial products, considering several thinnings before the final cutting.

The data came from 120 permanent sample plots with area of 500 m^2, installed in stands of *Pinus caribea* hondurensis plantations, located in the county of Agudos, State of Sao Paulo, Brazil. These stands are projected for a 25 years rotation age, and selective thinnings of the smallest and worse trees at ages of 8, 10, 12, 15, 19, and 22 years, reducing the number of trees per hectare to 1500, 1000, 700, 500, 300, and 200 respectively.

Several models for survival prediction were tested until the first thinning to predict the future basal area, average height, minimum diameter, average diameter and quadratic average diameter. Also they were developed mathematical expressions to express the thinnings, developed form functions to estimate commercial volumes and specifically expressions for estimating the number of trees and basal area present and future. The weilbull function was used for diameter distribution.

For all cases, the selected models presented a very good fit and unbiased estimations, It was found a great consistence of the diameter distribution in predicting the minimum and maximum diameters, being theirs estimated values very close to their actual values, including when the thinnings were simulated.

The behavior of the curves of basal area, volume, average height, presented as the expected biological pattern. The thinned number of trees, basal area and volume also presented very close to theirs actual values in 92% of the tested cases.

Finally it was concluded that the developed prediction system presented very satisfactory results with very reliable estimates of all considered variables.

FIRST RESULTS OF SINGLE TREE THINNING EXPERIMENTS

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FDC: 242: 181.65--015.5

Thinning experiments are normally guided by basal area or stem number of the remaining stand. The object of these experiments is the stand, not the single tree. Even if a great number of trees is measured, the degrees of freedom for statistical tests frequently are low. The plans for these experiments normally do not include replications of treatment with regard to single trees. Thus the reaction of single trees to specific changes of their growing space can be valued only in a limited range.

In 1983 the German Association of Forest Research Stations issued "Recommendations for yield science experiments for the observation of the reactions of single trees to different types of thinning," in which type, intensity and time of treatment (removal of trees) are defined in units of tree dimensions (dbh, height) and their mutual distances. Neighbour trees have to be removed, if the distance to the central tree is shorter than a distance limit (DL) calculated by a formula. The formula is:

$$DL = H/A * d/D,$$

where H = height of the central tree,
D = dbh of the central tree,
d = dbh of the neighbour tree,
A = coefficient guiding the intensity of thinning, fixed by the experimental program.

In Austria two thinning experiments have been installed according to these recommendations. The coefficient A in these experiments was 4, 5 and 6 respectively. Five years after the first treatment, significant differences of diameter- and volume-increment were found dependent on intensity of thinning.

The results of this early evaluation led to the conclusion that information about growth reactions to predefined neighbourhood conditions can be found by this method with rather low expenses. The calculation of thinning intensity by a formula guarantees reproducible neighbourhood conditions by means of an objective rule. It is proposed to discuss an international program of single tree thinning experiments

EFFECTS OF SPACING ON YIELD AND SOME WOOD PROPERTIES OF PINUS PATULA AT RONGAI, NORTHERN TANZANIA

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FDC: 232.43: 181.65: 815: 174.7 Pinus patula Schl. et Cham.

A Pinus patula spacing experiment located at Rongai, Northern Tanzania was assessed at the age of 19 years. The experiment was planted at square spacings of 1.13m, 1.46m, 1.88m, 2.43m, and 3.14m. Other than pruning to 1.8-2.0m at the age of three years and routine weeding, the experiment did not receive any other treatment. Assessment was made of survival, branch diameter, height, basal area, volume production, basic density, and wood strength. Except for the wood properties all other variables were significantly affected by spacing. Mortality decreased with increasing spacing while branch diameter, breast height diameter, basal area and volume production increased. The implications of these results on future management of Pinus patula in Tanzania are discussed.

Keyword: Spacing, yield, wood quality, Pinus patula

EFFECTS OF SIZE ON THE PRECISION OF GROWTH ON EXPERIMENTAL PLOTS

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FDC : 524.635: 564

Designed experiments in forestry are by nature long–term, expensive to perform, and occupy large areas of land. If there are many treatments to perform in a block there are often difficulties to find place for them in the same stand. Therefore it is very important to use optimum plot and block sizes to maximize the information from an experiment. In growth and yield research the aim is to be able to judge if there is a difference between treatments measured for example as growth per unit area. The needed plot area for an experiment must also be dependent on how many trees there are per unit area. If the experiment is supposed to last until final cut or if the experiment only should cover a limited time.

As a pilot study an analysis on the precision of the estimation on growth and its dependence on size is made. The field–data for this study comes from two permanent sample plots established 1918 and 1920. The plots are 0.4 and 0.5 hectare and the recorded 10 times over 50 years. The spatial position of the trees is known. At each examination the diameter at breast height was measured and registered individually. Height was recorded on sample trees.

The plots will be divided in 4,9,16 and 25 parts. Each part will be regarded as a new plot and the growth per unit area calculated. The relationship between the variance per plot (V) and the size (A) of the plot will be studied over time. The data will be analyzed with Fairfield Smiths law.

DISTANCE-DEPENDENT COMPETITION MEASURES TO MODEL GROWTH OF INDIVIDUAL TREES

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FDC: 561.2: 181.41: 232.43--01

Several distance-dependent competition measures were tested for modelling individual tree diameter growth, using data from a spacing experiment established in eucalypt plantations in Portugal. The indices tested include area overlap indices, point basal area, distance-weighted size-function indices and area potentially available. Single correlations with growth on a spacing X age basis were analysed for each index, as well as its behaviour in multiple linear regression equations for predicting growth of individual trees.

We tried also to analyse the results obtained in relation with the status and type of competition of each stand. The status of competition was evaluated through the observed diameter distribution and the relationship between mean plant basal area and density on log scales (C-D effect). The type of competition, symetric or assymetric, was assessed through observation of plots of relative diameter growth over diameter.

TODAYS CONCERNS ABOUT THE FOREST ECOSYSTEM AND WHAT THEY SUGGEST FOR FUTURE INVENTORIES AND MONITORING

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FDC: 905--01

SUMMARY

Over the past half century, inventory and monitoring of global forest resources have become more complex. Public concerns, and the information that is needed, have changed over time. The ability of resource inventory specialists to adequately answer upcoming questions depends heavily upon new technology, adoption of uniform standards and definitions, and cooperation that will bridge national policy constraints.

Keywords: Resource inventories, information needs, new technology

HISTORY AS A GUIDE TO THE FUTURE

In order to acertain where we are going in resource inventories in my country, it is necessary to see where we have been. The following tabulation illustrates the evolution of inventories in the United States in the past four decades and where we think inventories will be in the year 2000.

	Information needs:	Units of measure	Data collected	Date users
1950	Timber supply	board feet	tree bole/ growing stock	Local wood using plants
1960	Trends in timber supply	board feet	tree bole/ all trees	National wood manufacturers
1970	Supply/demand for forest resources	cubic feet	Vegetation, incl.	International wood manufacturers
1980	Wood for energy and nutient cycling	green tons	Above ground biomass	Multinational researchers and planners

1990	Forest health monitoring	dry tons	Forest ecosystem	Multinational technical experts
2000	Global warming	metric	Forest ecosystem	Global policy-makers

The Forest Survey, as it was called, started with a narrow support group--the local wood manufacturing industry--and collected detailed information on that portion of certain trees that constituted the raw material input for wood manufacturing plants.

Interest in timber supply soon gave way to interest in trends in supply, and the relationship between supply and demand. At this point, the focus of research was redirected from the accurate estimation of timber volume to growth, removals, and mortality estimation within the timber base.

In the 1970's, the United States forests were rediscovered as a valuable public asset and multiple resource management was popular. It became important to know relationships between trees and other vegetation in order to manage the land for many resources within the forest. Some emerging uses proved to be incompatable with existing uses and conflict followed between resource users.

The 1980's can be characterized by the recovery from a major global energy shock at the beginning of the decade and a shift in concern to forest health as we leave the decade. Our relatively small support group of the 1950's has expanded to include "the man on the street" who is concerned with last year's Yellowstone wildfire, major oil spills, the impending demise of old-growth timber and the northern spotted owl in the Pacific Northwest, and the general decrease in health of trees as man-made pollution increases.

Communications have improved immensely during the last half century. People are aware of things that happen everywhere in the world. Natural and man-made disasters, and their effects, are televised to the public and their concerns have become global in nature. Even timber industry is now drawing raw material from a global market and marketing their products in international trade.

So how will public concerns over global warming, forest health, biological diversity, and international resource use affect future inventories and the manner in which they are conducted?

INFORMATION NEEDS

Current and future concerns will affect the kinds of information we collect. We foresee a continuation of the long-term trend of measuring more than just the merchantable portions of certain preferred forest trees. Currently, a vegetative profile has been incorporated into the field data collection which determines horizontal and vertical vegetative distribution, density, diversity, and composition of the tree and other vegetation associated with forested ecosystems. Since species composition, level of stocking, and structural features of the stand influence the benefits derived from the forest, the vegetative makeup can be viewed as the common link for studying the interactions between resources and providing early indications of changes in forest health or the effects of global warming if the same sites are monitored over time.

In addition, new information related to the appraisal of visual damage will be collected. A system has been developed in Europe and is being tested in Scandanavia and North America. In theory this information should be collected in the same location and at the same time each year. The challenge will be to determine how to link this annual information to the traditional field locations so that the large body of existing information can be employed in analyzing effects.

There is a growing awareness of the importance of below-ground organic matter and how it effects ecosystem processes in temporate climates, yet we know very little about the extent and condition of this portion of the ecosystem. In the future we will need more information in order to complete the picture of the entire forest biomass, and to assist in future analyses of the interactions between forests and the environment.

A final very important consideration, which is often overlooked, is the extent that neighboring nations can achieve uniform standards and definitions to allow comparison of statistics across national and continental boundaries.

THE WORKING ENVIRONMENT

The traditional method of collecting forest inventory data in 1950 was to enter it on tally sheets and transfer the coded data to punch cards or tape for entry into the computer. A continuing problem with this procedure was the editing and transfer process that often occurred in the office many months after the field visit. Reconstructing erroneous field measurements was difficult and each time information was handled there was the possibility of introducing human errors.

day's electronic data recorders are proving invaluable in the field and ha transferred most of the editing function to the field. Since the recorders are also computers many complex operations will be performed and trend information can be monitored on site. In addition, global positioning systems (GPS) will facilitate the relocation of field plots and laser technology will be employed to increase the accuracy of field measurements. Geographic information system (GIS) technology is being implemented by many research and land management agencies thoughout the world. This technology provides a powerful analytical tool which will be invaluable in drawing together ancillary data from many sources when answers are sought about the causes of forest change or the effects of man-made pollution on the forest ecosystem. Development of GIS technology must proceed at a rapid rate to accommodate the needs of society. The remotely-sensed data layer and inventory generated data layer will be critical to the success of future analyses.

In the future, most inventory organizations will need dedicated computers to support the growing, more complex inventory task. Day to day functions will include data capture, editing, data reduction, statistical analysis, graphics, digitizing and geographic analysis, and processing of satellite data. Screening techniques will be a valuable option for the type of custom retrieval systems that will be necessary to answer area related questions that are geographically referenced. Also, in a relational computing environment, location of the data will no longer be a problem. Data bases in several locations will be queried for data and drawn into a single location to be compiled, or masses of data will be sent to a high-capacity machine for processing and the necessary information retrieved after the processing has been completed.

FINAL OBSERVATIONS

I began with an illustration of the evolution of inventory in the United States during the half century between 1950 and 2000. The following is a second tabulation that illustrates what the answers were, or will be, to the national questions of the past and the global questions of the future.

Decade	Answers to questions
1950	2,094 billion board-feet of sawtimber on commercial forest land measured by the International 1/4-inch log rule.
1960	Sawtimber inventory volume decreased by 1 percent (24 billion board feet) between 1953 and 1963.
1970	U.S. demand was projected from 8.8 billion cubic feet in 1970 to 11.1-15.1 billion cubic feet in 2000. Supply increased from 8.8 billion cubic feet in 1970 to 11.5 billion cubic feet in 2000.
1980	Total green weight of above-ground tree biomass was 36 billion green tons on U.S. timberlands.
1990	Total weight of all live trees on timberlands in the U.S. is 17.8 billion dry tons, or 36.9 dry tons per acre.
2000	Total carbon storage in all U.S. forests is about 50 billion metric tons, or 4 percent of the carbon stored in the world's forest ecosystems.

Today's national concerns are only reflections of concerns that will ultimately effect all nations. This is why a global network of scientific and research organizations are necessary to share developing technology, and why we are meeting at conferences such as this one in Montreal. Because of the emerging issues, inventories will find new partnerships in the biological sciences. Monitoring will require the remeasurement of field locations, a practice that is not being followed in some countries that have been conducting forest inventories for many years. The new technology will allow information to be linked in a spatial context and compared on a map base at some level of resolution with other data that will support analyses that were never possible before. I believe technology will not be the limiting factor for meeting the concerns of the future. An equal challenge will be bridging national policy constraints for the benefit of the entire globe. We are up to the technical task of the 1990's, and hope that society will accept the information we develop, and use it well.

POINT SAMPLING FOR BASAL AREA ESTIMATION IN EUCALYPT PLANTATION

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FDC : 521.62: 176.1 _Eucalyptus saligna_

A test of point sampling was made in a _Eucalyptus saligna_ plantation forests with 4 years of age in two region (flat and sloping terrains) in the state of São Paulo, Brazil.

Basal area values of 648 sq. m. plots and point sampling (basal area factor 2, 3 and 4 sq. m. per hectare) established at each plot center, were compared.

Point and plot sample average DBH, mean quadractic DBH and average total height estimates were estatistically significant. Between the three basal area factors there were no significantly difference for the three parameters studied. Basal area estimates were not significantly different, regarding plot and point sampling.

Approximately 9 times more point samples with basal area factor 4 should be necessary to equal 648 sq. m. plot accuracy in estimating basal area per hectare.

The number of trees tallied in each point sample with basal area factor 4 is 15 to 20 times lower than the number trees tallied in a plot sample.

EVALUATION OF THE AERIAL-PHOTO ANGLE-GAUGE SAMPLING TECHNIQUE FOR FOREST INVENTORY

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The Forest Inventory and Analysis unit of the USDA Southern Forest Experiment Station is charged with conducting continuous inventories of the forest resources of the Midsouth Region of the United States. New and innovative techniques that may improve the efficiency and accuracy of these inventories are in great demand. One such method that may be of benefit to the unit is angle-gauge sampling of tree crown diameters from aerial-photos. Successful implementation of this technique on an applications-basis could improve the timeliness of current ground-based forest surveys and allow efficient data collection in geographically remote locations.

The aerial-photo angle-gauge sampling technique was introduced by McTague (1988) for ponderosa pine (Pinus ponderosa Engelm.) stands in northern Arizona and involved the derivation of a technique for obtaining forest stand density from aerial photographs based on the principles of selection with probability proportional to size. This method was later applied to loblolly pine (Pinus taeda L.) stands in Louisiana by Gering and McTague (1988). Recently, the USDA Forest Service applied this sampling technique to an inventory of two counties in Tennessee and compared with results to the traditional ground-based inventory. This paper evaluates the angle-gauge sampling method.

SAMPLING AT THE STAND BOUNDARY: A COMPARISON BASED ON MEAN SQUARE ERROR OF SEVEN METHODS

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Mapped locations of 4676 trees on two contiguous stands (sapling and sawtimber) were used to assess the mean square error of several methods that have been proposed to eliminate or reduce the bias that results if neither the sampling nor estimation accounts for the altered probability of selection of trees near the stand boundary. A fixed-area circular plot was used to determine sample selection with all methods, and all methods were used to estimate number of trees, basal area, and volume per unit area. When no correction is made in the sampling or estimation phase, the usual estimator of a forest attribute is biased because edge trees have selection probabilities that are not proportional to the size of the plot. The "no-correction" approach was compared to three unbiased and biased methods, respectively. The unbiased methods included Grosenbaugh's (1958), the mirage method (Schmid-Haas 1969), and weighting each selected tree by a factor inversely proportional to its actual selection area when no correction is made to the sampling method. Among the biased procedures are those in which the plot center was relocated if it fell within a peripheral zone of fixed width inside the stand edge. In one case, the plot was relocated to the interior edge of the peripheral zone; in another, the plot was randomly located. The final biased procedure involved expanding the plot size inside the tract to compensate for the area of the plot that is truncated by the stand boundary.

The relative performance of the methods varied between the two types of stands and depended on the target attribute to be estimated. Based on the mean square error criterion, no method was clearly superior and some of the most biased methods often were better than the unbiased methods.

VARIANCE REDUCTION IN UNEO'S METHOD OF STAND VOLUME ESTIMATION

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Uneo's method can be used to estimate stand volume counting each tree whose critical height is greater than a randomly generated number. When this tree count is multiplied by an appropriate constant, an estimate of stand volume is obtained. It is proposed that a reduction in the variance of the stand volume estimate could be obtained by generating, for each tree, pairs of random numbers which are antithetic variates. These can be compared to the tree's critical height, and the "count" can be increased whenever the random number is less than the tree's critical height.

If u is chosen from a uniform distribution on the interval (0,1) then (1-u) is its antithetic variate, and also has a uniform distribution. In application to Uneo's method, a maximum height "H" would be selected prior to sampling and the numbers Hu and H(1-u) would be compared to the critical height of a tree selected by a horizontal point sampling angle gauge. Antithetic variates are sometimes used for variance reduction in Monte Carlo integration. Uneo's method can be viewed as a type of "hit or miss" Monte Carlo integration.

FOREST INVENTORY UPDATES FOLLOWING INSECT DEFOLIATION: LINKING STAND MODELS WITH REMOTE SENSING OF STAND CONDITION

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SUMMARY

Effective forest management planning requires an up-to-date forest inventory and accurate projections of future stand yields. Accurate inventories and yield projections are particularly important in the many regions with tight timber supply/demand balances. Use of Geographic Information System (GIS) technology by many agencies has facilitated management planning and opened many possibilities for inventory updating, but it also has increased the costs of inventory data bases. In this paper, we discuss inventory updating methodology being developed for use in New Brunswick, Canada, that involves linking stand models and remote sensing of stand condition.

Updating methodology will involve assessment of critical characteristics of individual stands by ground-based or aerial surveys or remote sensing, and the use of stand models to project development. Separate stand models are being developed for establishment, growth, and stable/decline phase stands. The two major factors causing rapid changes to New Brunswick's forest inventory are defoliation by spruce budworm (Choristoneura fumiferana (Clem.)) and a preponderance of mature and overmature stands that are close to breakup; both factors can result in reduced stand volumes. The mature and overmature stand updating system currently under development in a multi-agency, 1988-1992 project therefore includes: (1) annual detection of current defoliation at the stand level by aerial survey or airborne MEIS scanner, (2) periodic (five-year) assessment of stand condition (cumulative defoliation or net volume increment) using Landsat Thematic Mapper, and (3) a stand model which can utilize a five-year defoliation scenario, current stand condition, and the inventory stand description to project future stand yield. A description of each of these components is given, including the stage of development and probability of success, and the prognosis for inventory updating is discussed.

Keywords: forest inventory, spruce budworm, stand breakup, model, remote sensing

INTRODUCTION

Developing methods to project stand development and yield, and thereby update forest inventories, is one of the most important practical areas of growth and yield research. Normal stand development, through the establishment, growth, stable, and decline phases, results in substantial changes in stand volume, species composition, and the diameter distribution of trees. Normal development can be dramatically modified by harvesting, silviculture, and damaging agents. Specifically, insects, disease, and fire affect millions of hectares annually in Canada, with impacts ranging from growth reduction of trees to the loss of entire stands or forests. Between 1977 and 1981 in Canada, an estimated 107 million m^3 of timber was lost to pests each year, with spruce budworm (*Choristoneura fumiferana* (Clem.) and western spruce budworm (*Choristoneura occidentalis* Free.) causing 41% of this loss, wood decays 23%, hypoxylon cankers 10%, aspen defoliators 7%, mountain pine beetle (*Dendroctonus ponderosae* Hopk.) 5%, and miscellaneous defoliators, bark beetles, and diseases the remaining 14% (Sterner and Davidson 1982).

Forest inventories and stand yield projections which accurately account for these impacts are particularly important in the many regions with a tight balance between timber supply and demand. Timber supply analyses and forest management plan revisions are being conducted with increasing frequency (e.g., every 5 years) in order to accurately determine sustainable harvest levels, and these analyses must be based on up-to-date inventories and accurate yield projections. The use of Geographic Information System (GIS) technology in many jurisdictions has facilitated management planning and increased the possibilities of inventory updating, but it has also increased the costs of forest inventory data bases. Both the need for reliable forest management planning tools and the use of a more costly inventory provide impetus for the development of procedures for updating of, instead of redoing, the resource inventory.

In this paper, we will discuss the forest inventory updating methodology being developed for use in New Brunswick, Canada, which involves linking stand models and remote sensing of stand condition.

CONSIDERATIONS FOR FOREST INVENTORY UPDATING

Successful forest management involves (1) design of effective strategies to meet forest management objectives, (2) on-the-ground implementation of those strategies, (3) evaluation of their effectiveness, and (4) timely response to divergence between expected and actual resource performance. Fundamental to these four tasks are the forest inventory, which constitutes the information base describing the present state of the resource, and stand development models, which are employed to forecast future characteristics of the resource under any contemplated strategies.

In this context, the inventory plays two important roles. First, it is used to initialize stand development models and second, it provides the basis for evaluating the accuracy of forecasts in foretelling the future. An inaccurate inventory, whether it is inaccurate at the time of compilation or becomes inaccurate due to failure to reflect resource changes, will perform these roles poorly and have direct negative impacts on the quality of resource management.

For this reason, inventory updating is a critical prerequisite to effective forest management. Inventory updating becomes even more important as more and more forestry agencies develop GIS-based inventory systems. Such inventories are considerably more expensive than traditional ones and afford sophisticated planning capabilities with which to develop suitable management strategies. Failure to update an inventory incurs two significant costs. First, it necessitates more frequent massive expenditures to reinventory the forest as existing inventories become obsolete in the absence of comprehensive updating procedures. The second, and perhaps more important, cost is the diminished reliability of planning tools when input information becomes out of date, thus rendering the planning results highly uncertain and less likely to be acted upon. In other words, the results from sophisticated, GIS-based planning tools will only be as accurate as the input inventory data.

While the cost of GIS inventories makes updating more important, the availability of GIS utilities makes inventory updating more practical and provides an avenue by which to introduce remote sensing as a powerful update tool. In this paper, we will discuss inventory updating activities in New Brunswick which capitalize on GIS technology and developing remote sensing technology. Since there are various forces that change the resource and thus create the need for updating, there are various methodologies in place by which to perform the necessary updates. Erdle and Andrews (1990) reviewed many of the update procedures in place in New Brunswick, including those for partial and complete harvesting, road construction, fires, and silviculture activities. Our focus here will be primarily on updating procedures related to insect defoliation and stand development.

EFFECTS OF FOREST PESTS ON INVENTORIES

A recent review of the effects of forest pests on stand growth and timber yield indicated that, for most pests, data are incomplete and relationships are poorly understood (MacLean 1990). Nevertheless, timber supply analyses for specific areas of forest have indicated that maximum sustainable harvest may be reduced by up to 60% by a severe spruce budworm outbreak (MacLean and Erdle 1984, Wang 1986). During an uncontrolled spruce budworm outbreak, merchantable stand volume can decrease by 60% or more during a five-year period (MacLean and Ostaff 1989). Serious overestimation of inventories and timber supply can, therefore, result from the failure to allow for catastrophic or even continual, small losses caused by biotic agents.

To predict the effects of pests, tree growth rates, mortality, and volume yield must be quantified and modelled for various degrees of pest severity, tree species, stand types, and stand ages. Once effects on stands are quantified, it is necessary to evaluate those effects in a forest-level context for use in management planning. The mechanics of this process will differ with the planning models used but, basically, deviations from expected yields, such as growth losses and mortality, must be incorporated into yield functions used in the supply models. This also requires determining or postulating the long-term dynamics of the damaging agent (MacLean 1990).

When models to forecast stand-level effects of pests are available, they can be used in four ways: (i) to derive more accurate estimates of the current inventory, future timber supply, and sustainable harvest levels; (ii) to define the degree of protection required in particular stand types to meet specified yield targets; (iii) to determine priorities for protection; and (iv) to refine harvest schedules to reduce losses caused by pests (MacLean 1990). Use of such models allows protection planning to be integrated into forest management planning to better determine protection priorities for individual forest management units and thereby design improved protection strategies (Erdle 1989).

Effects of pests are particularly important when timber supply and demand are in tight balance. Under such circumstances, timber supply planning must include rigorous scheduling of harvest to avoid timber shortfalls and decisions must be made about the costs, benefits, and relative priorities of silvicultural and protection activities. Any timber supply forecast must have as its basis an accurate measure of the current inventory and realistic stand yield projections.

The inclusion of catastrophic losses in timber supply forecasting is critical if predictions are to be accurate. Planning for a sustained timber supply is an iterative process, whereby the initial forest inventory is periodically updated and projected into the future. Allowing for catastrophic losses before the fact (i.e., on a probabilistic basis) is most important when there is a high risk of occurrence, a large potential impact on forest yield, or a long period between successive iterations. Otherwise, it may be more realistic to account for actual losses of timber which occur by adjusting (reinitializing) the forest state at the beginning of the next iteration.

SPECIFICS OF THE NEW BRUNSWICK SITUATION

The Forest Resource and Forest Management Problems

Forests in New Brunswick extend over six million hectares and are comprised of over one million individual stands. The age class structure shown in Figure 1 reveals the impact of past harvesting and episodic spruce budworm outbreaks. In fact, the 70-year-old age class which dominates the forest arose after a severe budworm outbreak which occurred between 1910 and 1920 (Swaine and Craighead 1924). Spruce (*Picea* sp.) and balsam fir (*Abies balsamea* (L.) Mill.) stands make up nearly 40% of the forest resource by

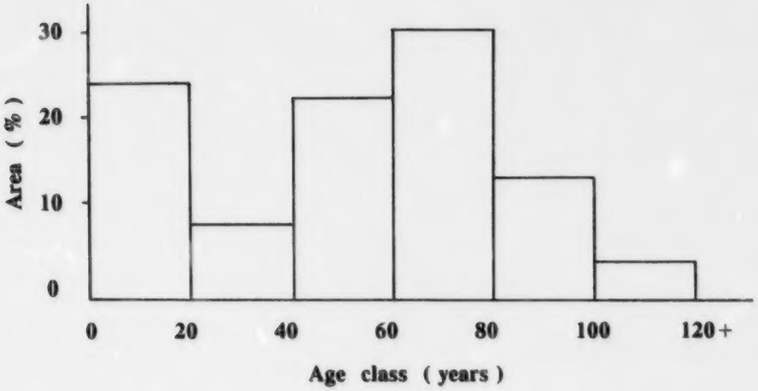

Figure 1: Age class structure of forest stands in New Brunswick, which has resulted from past harvesting and spruce budworm outbreaks.

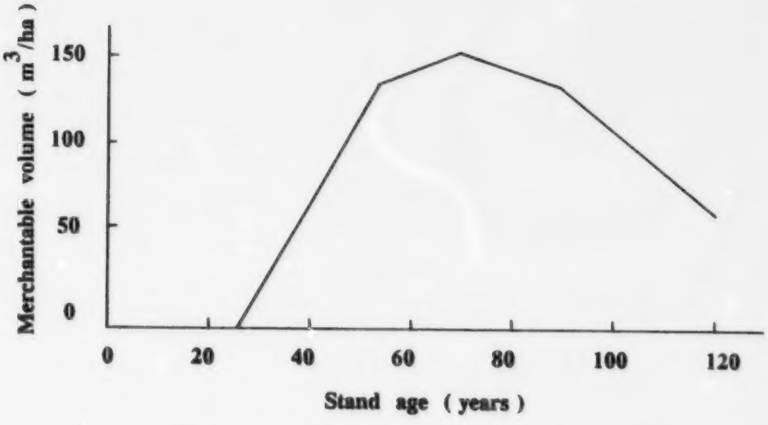

Figure 2: A typical volume development pattern for spruce-fir stands in New Brunswick.

area. Figure 2 presents a typical yield pattern for spruce-fir types in New Brunswick; the relatively short-lived nature of these species exacerbates problems of controlling wood supply. Since much of the area (Figure 1) resides at a point of net yield decline (Figure 2), the importance of preempting volume loss through judicious harvest scheduling and arresting volume loss through judicious protection becomes obvious.

Both an accurate inventory and realistic yield projections are required to support the design of effective harvest and protection measures. These requirements have resulted in the update and forecasting efforts undertaken in New Brunswick.

Current Status of the Inventory and Planning Procedures

Partly in response to the management problems posed by the New Brunswick forest structure and natural yield patterns of the dominant spruce-fir types, substantial efforts in forest inventory compilation and design of management planning methodology have been undertaken.

In 1982, a new provincial inventory was initiated and an ARC/INFO GIS was acquired as the vehicle for storing and using the resulting inventory data base. The Crown Lands and Forests Act, enacted in 1982, set out a policy for management planning that includes geographic representation of sustainable timber harvest and silvicultural strategies. A five-year planning cycle sets the context for inventory use in management design, and inventory activities are scheduled to make incremental improvements in the data base and yield forecasting procedures at the start of each new planning cycle.

The planning effort in each five-year cycle serves to identify existing shortcomings in both the inventory and yield forecasting procedures and these then focus on the most productive areas for potential improvement during the next period. The inventory updating and forecasting developments described below were initiated in response to the most urgent problems identified in the 1987 management planning cycle and, if successful, should be operational by the next cycle, beginning in 1992.

Forest Resource Changes and Updating Requirements

The two primary factors causing rapid depletion of New Brunswick's forest inventory are outbreaks of spruce budworm, a defoliator of balsam fir and spruce, and a preponderance of mature and overmature stands which are approaching breakup and declining in volume. Three spruce budworm outbreaks have occurred in the 20th century, starting about 1910, 1940, and 1970 (Blais 1983). The most recent outbreak affected about 57 million hectares of forested land in eastern Canada and the United States and, by 1981, about 23 million hectares contained significant volumes of dead and dying timber (Kettela 1983). Because of the destructive potential of spruce budworm defoliation, a forest protection program has been used in New Brunswick since the early 1950s to control damage by spraying biological and chemical insecticides. Timber supply analyses for a 195,000 ha forest in New Brunswick indicated that the range of wood supply uncertainty resulting from different degrees of spruce budworm defoliation and protection was at least ±25% (Wang 1986). An improved understanding of the impact of defoliation on stand growth is essential to reduce this uncertainty.

Inventory updating requirements and procedures in New Brunswick differ for stands with different maturity or development stages. This is because available inventory data and the factors governing stand growth differ between development stages. Therefore, models are being developed for the establishment phase (regenerating), the growth phase (25 to 50 years old), and the stable/decline phase (mature and overmature) stands (Figure 3). The stable/decline phase is of considerable importance because much of the forest is mature or overmature and these types are strongly influenced by natural breakup and pests. The behavior of these stands will exert the greatest effect on short term (25-year) timber supply. Consequently, the stable/decline phase is the focus of much of the current research efforts on updating methodology.

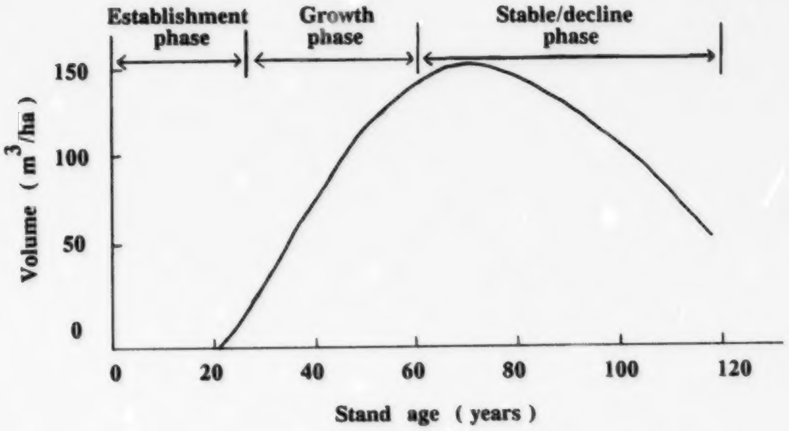

Figure 3: Generalized stages of spruce-fir stand development. Different forest inventory updating procedures are being developed for the establishment, growth, and stable/decline phases.

A FOREST INVENTORY UPDATING SYSTEM FOR NEW BRUNSWICK

Some of the components necessary to project effects of management and impact on forest inventory and sustainable harvest are available in certain regions, but no complete, integrated, forecasting system has ever been developed. Development of such a forest management planning system is currently underway in New Brunswick under the auspices of the New Brunswick Forest Research Advisory Committee. The objective is to produce an operational system by 1992, which can be used to update the forest inventory, assist in determining sustainable harvest levels, and reduce the ±25% uncertainty in future timber supply attributable to spruce budworm. Inventory updating methodology will generally involve assessment of critical characteristics of individual stands by ground-based or aerial surveys or remote sensing, and then use stand models to project stand development.

For stable/decline phase stands, this means addressing relative growth and mortality rates and the alteration of these rates (reduced growth and increased mortality) caused by spruce budworm defoliation. An inventory updating system for these stands is currently under development for New Brunswick in a multi-agency, 1988-1992 project (MacLean et al. 1987). The proposed system comprises three components: (1) annual detection of current defoliation at the stand level by aerial survey or airborne MEIS (Multispectral Electro-Optical Imaging Scanner) scanner, (2) periodic (five-year) assessment of stand condition (cumulative defoliation or net volume increment) using Landsat Thematic Mapper, and (3) a stand model which can use a five-year defoliation scenario, current stand condition, and the inventory stand description to project future stand yield.

The probabilistic stand model is under development by the Applied Forestry Technology Group at the University of Moncton, the New Brunswick Department of Natural Resources and Energy, and Forestry Canada. The model, given an initial description of stand condition and the amount of defoliation, can be used to predict mortality and survivor growth in mature or overmature softwood stands. It is designed to project the development of a specified diameter distribution of trees in a stand over a specified time interval, incorporating the processes of diameter growth and mortality and effects of cumulative defoliation.

To update mature and overmature stands in the inventory, stand development in a five-year period will be accounted for using the model and an assessment of stand condition. Stand condition may be assessed either by directly measuring cumulative defoliation at the end of the period or by accumulating the current annual defoliation over the last five to seven years. The potential for using remote sensing technology in damage detection and forecasting is high. Research is required to realistically assess the survey technology presently or potentially available, the levels of precision required, and the costs. To this end, a four-year project, involving the Canada Centre for Remote Sensing, Forestry Canada, New Brunswick Department of Natural Resources and Energy, and University of Moncton, was begun in 1988 to evaluate the use of remote sensing to assess stand condition and annual defoliation. Ahern et al. (1990) found a highly significant relationship between net annual change in timber volume of spruce-fir sample plots and vegetation condition indices involving the mid-infrared and near infrared reflectance observed by Landsat Thematic Mapper. Therefore, the project includes evaluation of the use of periodic Thematic Mapper data to determine cumulative defoliation and stand condition (Dupont et al. 1989) and the use of an airborne MEIS scanner to replace the current aerial sketch mapping survey of current-year defoliation. From 1986 to 1988, 42% of the annual aerial sketch mapping defoliation estimates (using classes of nil, light <30%, moderate 31-70%, and severe 71-100%) for 126 plots were correct (based on comparison with detailed ground-based defoliation estimates), 84% were ±1 class, and 99% were ±2 classes (MacLean, unpublished). Developing a remote sensing method for rating defoliation could result in greater accuracy by eliminating subjective observer ratings and also allow assessment of stand-level defoliation for all stands in the forest.

The inventory updating system being developed in New Brunswick will also be used to forecast future timber supply and plan protection programs. Under the proposed system, stand- or block-level surveys of budworm populations, current defoliation, and cumulative defoliation would be used to forecast future defoliation, which, in turn, would be used in a stand growth model and timber supply model to forecast potential stand- and forest-level impacts (MacLean et al. 1987). Protection priority of stands in each forest management unit would then be assigned, based on the marginal, forest-level wood supply impact of protecting or not protecting different types of stands, using a system developed by Erdle (1989). Advantages of the system are that (1) it quantifies the impact of protection in units relevant to the objective for which protection is employed (i.e., wood supply) and (2) it establishes a priority queue for protection so that, for any budget level, each dollar spent returns the maximum wood supply (Erdle 1989).

THE PROGNOSIS FOR INVENTORY UPDATING

Erdle and Andrews (1990) discussed the effects of GIS technology on the future evolution of forest inventory practices, and made the following four projections: (1) electronic remote sensing will replace conventional photography as the main data source for forest inventory; (2) there will be a transition from the concept of reinventory to one of inventory revision, in which features in the initial inventory are retained and the condition of all stands is revised to reflect changes which have occurred; (3) inventory programs will become more sophisticated, more comprehensive, more expensive, and more accurate, in part because the switch from reinventory to inventory revision extends the useful life and thus the value and utility of information; and (4) forest inventories will change from merely providing current status to explicitly defining expected future status as well. Use of procedures to forecast stand development and the opportunity to reconcile forecast and actual stand behavior will undoubtedly result in the development of more sophisticated forest inventory updating procedures.

Improved understanding of the impact of pests on stand yield, and methods to incorporate this information into forest inventory updating and timber supply analyses, are essential prerequisites to reduce uncertainty about current and future timber supplies. The effort underway in New Brunswick is designed to improve this understanding. The approach applies sound research methodology and state of the art technology in information acquisition and management to an important practical forest management problem. In the short term, the objective is to make significant improvement in addressing defoliation impacts to benefit upcoming operational forest management planning in 1992. While there is no guarantee of success, clear definition of the management problem, clear specification of the timetable and context for application, and cooperative involvement of forest managers and researchers makes the probability of success high.

ACKNOWLEDGEMENTS

Many members of the New Brunswick Forest Research Advisory Committee "Budworm Impact", "Forest Insect and Disease", and "Growth, Yield and Wood Supply" Technical Committees played a role in proposing and reviewing the 1988-1992 applied budworm research plan and forest inventory updating procedures for New Brunswick, and the help of all is acknowledged. In particular, E. Wang, N. Carter, and H. Piene should be mentioned for major efforts toward incorporating spruce budworm impact into forest management planning in New Brunswick. Cooperators in various aspects of the remote sensing and stand modelling projects currently underway include F. Ahern, O. Dupont, C. Frame, D. Leckie, S. Poirier, J. Steinman, K. Topolniski, eight forest products companies in New Brunswick, the New Brunswick Department of Natural Resources and Energy, and Forestry Canada.

LITERATURE CITED

Ahern, F.J., Erdle, T., MacLean, D.A., and Kneppeck, I., 1990: A quantitative relationship between forest growth rates and Thematic Mapper reflectance measurements. International Journal of Remote Sensing, vol. 10, in press.

Blais, J.R., 1983: Trends in the frequency, extent, and severity of spruce budworm outbreaks in eastern Canada. Canadian Journal of Forest Research, vol. 13, pp. 539-547.

Dupont, O., Poirier, S., Ahern, F.J., and MacLean, D.A., 1989: Évaluation des données du Thematic Mapper pour les prévisions de croissance forestières au Nouveau-Brunswick. In Proceedings of the 12th Canadian Symposium on Remote Sensing, Vancouver, British Columbia, July 10-14, 1989. Vol. 3, pp. 1580-1584.

Erdle, T.A., 1989: Concept and practice of integrated harvest and protection design in the management of eastern spruce-fir forests. Ph.D thesis, University of New Brunswick, Fredericton.

Erdle, T.A., and Andrews, P.W., 1990: Updating and maintenance of a GIS-based forest inventory. Proceedings of the GIS '90 Symposium, March, 1990, Vancouver, British Columbia, in press.

Kettela, E.G., 1983: A cartographic history of spruce budworm defoliation 1967 to 1981 in eastern North America. Forestry Canada, Ottawa, Ontario, Information Report DPC-X-14.

MacLean, D.A., 1990: Impact of forest pests and fire on stand growth and timber yield: implications for forest management planning. Canadian Journal of Forest Research, vol. 20, in press.

MacLean, D.A., and Erdle, T.A., 1984: A method to determine effects of spruce budworm on stand yield and wood supply projections for New Brunswick. The Forestry Chronicle, vol. 60, pp. 167-173.

MacLean, D.A., and Ostaff, D.P., 1989: Patterns of tree mortality caused by an uncontrolled spruce budworm outbreak. Canadian Journal of Forest Research, vol. 19, pp. 1087-1095.

MacLean, D.A., Wang, E.C., and Carter, N., 1987: A framework for applied budworm research. New Brunswick Forest Research Advisory Committee, Fredericton, 16 p.

Sterner, T.E, and Davidson, A.G., 1982: Forest insect and disease conditions in Canada, 1981. Forestry Canada, Ottawa, Ontario.

Swaine, J.M., and Craighead, F.C., 1924. Studies on the spruce budworm (Cacoecia fumiferana Clem.). Canada Department of Agriculture, Ottawa, Technical Bulletin Number 37 [New series], 91 p.

Wang, E.C., 1986: Toward reducing wood supply uncertainty. New Brunswick Executive Forest Research Committee Inc., Fredericton, 49 p.

March 1, 1990

THE EFFECTS OF AGGREGATION ON DOUGLAS-FIR YIELD PROJECTIONS ESTIMATED WITH INDIVIDUAL TREE AND STAND-BASED GROWTH MODELS

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This study examines the effects of several methods of aggregation on the mean yields obtained by projecting a sample of Forest Inventory and Analysis (FIA) timberland plots. Plots selected for this study are located in undisturbed young-growth Douglas-fir stands on non-National Forest lands in western Washington. Tree lists are aggregated from the subplot level to plot, stratum, and broad forest type levels of aggregation. For each level, the tree lists are projected 20 years using an individual tree-based growth simulator, the Stand Projection System (SPS) and a stand-based growth model, the Douglas-fir Simulator (DFSIM). For the two sets of projections, mean yields are computed for each level of aggregation and compared to mean yields compiled from successive measurements on the plots.

THE INTEGRATION OF REMOTELY SENSED DATA WITH GIS FORESTRY DATABASES IN NEW BRUNSWICK

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In the early 1980's a Provincial Task Force reviewed the future availability of the spruce-fir resource for the Forest Products Industry of New Brunswick. The task force concluded that if the level of production, at that time, was to be maintained it would be necessary to institute a program of intensive forest management in the Province. The elements of intensive forest management were defined as modern technology to determine the state of the forest and predict the availability of future wood supply and, once the dynamics of the forest were understood, a silvicultural program to increase production. Remotely Sensed Data, GIS databases and Growth and Yield Models were identified as technology that would assist in understanding the dynamics of the forest.

Remote sensing technology offers an opportunity to eliminate the tedious task of traditional photo interpretation. The input of our remote sensing system will be geometrically corrected to the New Brunswick Stereographic Projection System. We can then identify changes in land use such as new roads, cuts, burns and blowdown shortly after they occur. Forest insect and disease problems have a major impact on wood supply and in New Brunswick. The spruce budworm is the major source of concern. We have developed methods for locating affected areas with satellite technology (Landsat-TM). At the present time, this tool is an aid in the mapping of insect and disease problems.

CONSTRUCTION OF STEM VOLUME AND BIOMASS TABLES OF ALDER

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FDC: 524.315: 537: 176.1 Alnus glutinosa Gaertn.

SUMMARY

Alnus glutinosa Gaertn. subsp. barbata (C.A.Mey.) Yalt.) is an taxon of Alder (Alnus Mill.) and ranges in the east Black Sea region of Turkey. Wenn it was looked at the literature cited in this taxon, it will be understood that there are many researches and publications related to its botanical, morphological, technological, polinological characteristics and its range, ecological and silvicultural requirements. On the other hand, there is no enough research on the yield and management basis of Alder forests. Therefore construction of Stem Volume Tables and Dry-Weight Tables and calculation of energy capacity of Alder state forests are the objects of this paper.

Keywords: Biomass, volume table, energy capacity, Alder

INTRODUCTION

Because of the predicted shortage of fuel energy, forest biomass is destined to become an important source of Turkey's energy supply. General directorate of forestry has established as of the of 1988, 390.000 ha energy forest.

EXPERIMENTAL METHODS

Local - and Standart Stem Volume Table were constructed by means of the material collected at the 510 sample trees, were choosen in 55 trial plots within 20m - 1610m altitude girdle.

The volume models of Kopezky-Gehrhardt and Schmacher-Hall were choosen in 7 volume models for construction of Local Stem Volume Table and Standart Stem Volume Table and Standart Stem Volume Table. Standart Volume Table was found suitable for Alder Forests of east Black Sea region as a result of diffrent controls on real and table volume data of sample trees. The equations were given below:

$$V = -\ 0.0188 + 7.00423.d^2 \qquad (1)$$

$$V = 0.4047.d^{1.9289}.h^{0.9438} \times 1.006 \qquad (2)$$

where V is expressed in m^3, d (dbhob) in centimeters, and h in meters.

In this study constructed Dry-Weight Tables are the first examples on this subject in Turkey. It can be possible to learn the dry-weight of diffrent components of Alder (stem wood, stem bark, live branches, twigs and leaves) and whole tree by measuring of b.h.d. and height of standing trees and reading at the dry-weight tables.

Dry-Weight Tables constructed by means of material collected on the 86 sample trees were choosen in 19 trial plots in the east Black Sea region within 10m - 1520m altitude girdle. Sample plots were established 0.04 ha in size in stands of varoius maturity stages and site and density classes within the specified population. The ovendry mass model was choosen in 5 ovendry models for construction of Dry-Weight Tables. Dry-Weight Tables were constructed using Alemdag's (1980) method. The equations were given below:

Stem wood $OM = -30.817 + 0.225.d^2 + 3.034.h$ (3)

Stem bark $OM = 1.429 + 0.020.d^2 + 0.119.h$ (4)

Live branches $OM = 0.643 + 0.011.d^2 + 0.135.h$ (5)

Twigs and leaves $OM = 1.669 + 0.005.d^2 - 0.054.h$ (6)

Total tree $OM = -27.076 + 0.261.d^2 + 3.234.h$ (7)

where OM is ovendry mass of components or of whole tree and expressed in kilograms, d(dbhod) in centimetres and h in metres.

The energy capacity of Alder state forests was calculated and given below:

Table 1: Energy capacitiy of Alder state forest in the east Black Sea region of Turkey.

Stem wood Kcal	Stem bark Kcal	Branches Kcal	Whole tree Kcal
$2.855.049 \times 10^7$	348.487×10^7	212.521×10^7	$3.416.057 \times 10^7$
t fuel-oil	t fuel-oil	t fuel-oil	t fuel-oil
2.855.049	348.487	212.521	3.416.057

LITERATURE CITED

Alemdağ, I.S., 1980: Manual of data collection and processing for the development of forest biomass relationships. Can. For. Serv., Pet. Natl. For. Inst-, Inf. Rep. PI-X-4, 38 p.

Saracoğlu, N., 1988: Construction of stem volume and biomass tables of Alder. Ph.D. Thesis, Trabzon, 112 p.

Saracoğlu, N., 1990: Energy capacity of Alder state forests in the Black Sea region of Turkey. Orman Mühendisliği,no.1, pp. 19-21.

THE ESTIMATION OF GROWTH, SITE ASSESSMENT AND TIMBER PRODUCTION FORECASTING FROM FOREST INVENTORY IN NORTHERN IRELAND

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There are 58 006 ha of state owned forest plantations in Northern Ireland managed as commercial high forest. Eighty-nine percent of this forest was planted since 1949. The forest area was stratified into 5 age classes and sampled by 2100 randomly placed permanent sample plots. Measurements were made in the winter months between 1985 and 1988 to provide data for estimating standing volume and growth, site assessment, timber production forecasting and the development of yield models. Statistical methods were used to determine the optimum number of old and new plots to be measured in each stratum on each occasion, and for the combination of successive measurements of individual plots to maximise the precision of the required estimates.

MODELLING TREE SPECIES MIGRATION IN RESPONSE TO CLIMATIC CHANGE

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If predicted major changes occur in global climate, impacts upon forest growth and survival could be unprecedented. Under a worst-case scenario, many species will survive only through their ability to migrate northward with sufficient rapidity. Previous estimates of species migration rates in northeastern United States have been deduced from the pollen record. Though useful, this approach disregards the unusual climatic edaphic, and biological conditions that existed during the early postglacial period; for example, soils were immature, shallow, and unsuited to many of the more demanding species. A second approach for detecting and measuring species migration rates is the remeasurement of permanent plots -- a longterm proposition. A third approach to detecting migrational change and predicting rate of movement is based on the fact that migrating species develop advancing or retreating fronts -- like weather fronts -- where maximum age plotted over distance or elevation forms a descending linear or curvilinear trendline. The slope of the trend provides a means for estimating migration rate. The intricacies of sampling for this trendline are discussed as well as approaches to analysis and modelling techniques.

ESTIMATION SUR PIED DES VOLUMES DES ÉPINETTES NOIRES ET DES PESSIÈRES NOIRES DE LEBEL-SUR-QUÉVILLON

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RÉSUMÉ

Le tarif à simple entrée paramétré par la valeur moyenne du rapport de la hauteur au diamètre des arbres dominants du peuplement est plus performant que les tarifs généraux à double entrée. Lorsque l'inventaire détaillé du peuplement n'est pas disponible, la surface terrière à l'hectare combinée à la hauteur dominante permet d'estimer le volume à l'hectare au fin bout et celui à la découpe de 9 cm avec 11 à 12 % d'erreur. Par contre, l'application de la loi de Eichhorn, c'est-à-dire l'utilisation exclusive de la hauteur dominante ou hauteur moyenne pour estimer les volumes à l'hectare, est certainement rapide mais son exactitude absolue n'est pas garantie car le taux d'erreur est élevé (40 à 43 % d'erreur). L'utilisation de la fonction de Weibull pour représenter la distribution diamétrale des pessières noires (Picea mariana Mill.) étudiées permet de confirmer la capacité du diamètre moyen du peuplement de prédire les proportions du volume à l'hectare par catégories de grosseur. Ceci est intéressant pour la gestion forestière à grande échelle des pessières noires boréales, car le diamètre moyen du peuplement permet d'estimer rapidement et à faible coût le volume sur pied ventilé par catégories de grosseur. Les proportions du volume par catégories de grosseur sont indépendantes du niveau de production.

ABSTRACT

The one-entry volume table parametrized by the mean ratio of height to diameter of dominant trees in a stand, is more accurate than general two-entry volume tables. When the detailed inventory of the stand is not available, the combined use of basal area per hectare and dominant height estimates the volume per hectare to top height and to 9 cm top, with 11 to 12 % error. Conversely, the application of Eichhorn law i.e. the exclusive use of dominant height or mean height to estimate the volumes per hectare is fast, but not completely exact, maybe 40 to 43 % error. Weibull function when used to represent the diametral distribution of studied black spruce stands (Picea mariana Mill.) confirms the capacity of the stand mean diameter to predict the proportions of the volume per hectare by size classes. This result is interesting for the large scale management of boreal black spruce stands, because the mean diameter of the stand can be used to estimate quickly and inexpensively the standing volume distributed by size classes. The proportions of the volume by size classes are independent to the production level.

INTRODUCTION

Dans le cadre de recherche de méthodes pour augmenter la fiabilité d'estimation des volumes sur pied pour les besoins d'aménagement des pessières noires boréales (Picea mariana Mill.), nous nous proposons de :

(1) construire les tarifs à simple entrée paramétrés au moyen des caractéristiques dendrométriques du peuplement pour estimer le volume marchand et le volume total de l'épinette noire dans la région de Quévillon;

(2) construire les tarifs de cubage de peuplements basés sur leur caractéristiques simples pour estimer le volume marchand et le volume total à l'hectare;

(3) vérifier la capacité du diamètre moyen du peuplement de prédire la répartition du volume à l'hectare par catégories de grosseur.

MATÉRIEL

Les peuplements étudiés sont des pessières noires faisant partie de la région forestière boréale, section B4- Argiles du Nord de Rowe (1972). Empruntées de Dubé et collab. (1982), les statistiques climatologiques de la région sont : durée de la saison de croissance (température seuil 5°C) entre 166 et 173 jours; début de la saison de croissance entre le 30 avril et le 4 mai; fin de la saison de croissance entre les 11 et 15 octobre; durée de la période sans gel entre 79 et 93 jours. D'après Rowe (1972), les précipitations moyennes annuelles sont de 800 mm dont la moitié se produit durant la saison de croissance.

Les données proviennent de 26 stations d'étude circulaires de 0,10 ha. Dans chaque station, tous les arbres de dhp supérieurs ou égaux à 9 cm sont dénombrés, leur hauteur totale est mesurée et cinq arbres de la strate dominante font l'objet de l'analyse de tige. Au total, 127 épinettes noires ont été prélevées dans 26 stations d'étude. De chaque arbre abattu, des rondelles de 4 cm d'épaisseur ont été prélevées d'abord à 0,4 m de la souche, ensuite à 1,3 m et ainsi de suite par billon d'un mètre jusqu'au fin bout de 2 cm de diamètre. Pour chaque rondelle, la mesure des largeurs de cerne se fait par période de 5 cernes sur quatre rayons disposés à angle droit à partir du centre de la rondelle, le premier rayon étant décalé de 22,5 degrés par rapport au plus grand diamètre de la rondelle. Ainsi, l'analyse de tige d'un arbre agé de 200 ans par exemple génère 40 observations.

CRITÈRES DE PERFORMANCE

Deux critères de performance sont utilisés: l'erreur en pourcentage sur la valeur observée et le biais estimé en pourcentage. Basé sur le test du Chi-2, le premier critère mesure l'amplitude des écarts entre les volumes estimés par le tarif et les volumes réels. Au seuil de signification de α = 0,05, l'erreur sur la valeur observée s'exprime en pourcentage par (Freese 1960):

$$P_2 = \frac{(1{,}96\text{x}100)^2}{\chi^2} \sum_{i}^{n} \left(\frac{\hat{v}_i - v_i}{v_i} \right)^2 \qquad (1)$$

où P est l'erreur en pourcentage, χ^2 la valeur tabulée du Chi-2 à n degrés de liberté et à $\alpha = 0{,}05$, $\hat{v}_i$ le volume estimé par le tarif de cubage, v_i le volume observé, 1,96 la valeur bilatérale de la normale standardisée à $\alpha = 0{,}05$, et n le nombre d'observations de dhp supérieur à 9 cm, générées par l'analyse de tiges abattues dans une station. Il convient de rappeler ici que le volume observé est le volume réel cubé par billon de 1 m lors de l'analyse de tige.

Le problème du biais causé par la transformation logarithmique de l'équation allométrique étant résolu par l'utilisation de la méthode de Baskerville (1972), le deuxième critère appelé biais estimé en pourcentage sert à déceler une sous-estimation ou une sur-estimation systématique de l'ensemble des volumes estimés par le tarif dans une station. Il s'écrit:

$$\text{Biais \%} = 100 \text{ x } \frac{\sum \hat{v}_i - \sum v_i}{\sum v_i} \qquad (2)$$

ESTIMATION SUR PIED DES VOLUMES DES ÉPINETTES NOIRES: TARIF DE CUBAGE PARAMÉTRÉ

Hummel (1955) a constaté que, dans un peuplement donné, la relation entre le volume marchand (par exemple le volume à la découpe de 9 cm correspondant à $(\pi/4)0,9^2 \simeq 0,6362$ dm² de surface terrière) et la surface terrière de l'arbre est représentée adéquatement par une droite. Cette constatation permet d'établir le tarif local pour chaque peuplement par l'équation suivante:

$$v_m = b_m(g - 0,6362) \qquad (3)$$

où b_m est la pente de la droite et g la surface terrière en dm².

Pour tenir compte de l'hétérocédasticité, la valeur de b_m s'estime par les moindres carrés pondérés:

$$b_m = \frac{\sum_{i}^{n} \left(\frac{v_{mi}}{g_i - 0,6362} \right)}{n} \quad ; \quad i = 1,..., n \qquad (4)$$

n étant le nombre d'observations dans une station, le poids utilisé est $(g_i - 0,6362)^2$.

Les données de l'analyse de tiges permettent d'estimer les valeurs du coefficient b_m pour chaque station (tarif local). Les diverses valeurs de b_m sont présentées au tableau 1. Si les 26 stations sont représentatives de la variabilité rencontrée dans l'ensemble des peuplements de Quévillon, ces valeurs auraient pu constituer la gamme des tarifs pour cuber les épinettes noires de la région. Cette gamme est inutilisable puisqu'il n'existe pas de paramètre du peuplement qui permet d'y entrer. Le problème consiste donc à trouver parmi les paramètres dendrométriques du peuplement présentés au tableau 1 (âge moyen, dhp moyen, hauteur moyenne et rapport moyen de la hauteur sur le dhp des arbres dominants H_0/D_0) ceux qui sont les plus corrélés avec b_m. Les corrélations entre les paramètres retenus de la station et la pente b_m (tableau 2) montrent clairement que le rapport H_0/D_0 est le paramètre recherché. L'approximation de la relation entre H_0/D_0 et la pente b_m par une droite (figure 1) permet d'établir le tarif paramétré pour le volume marchand:

$$v_m = (-0,8293 + 111,3982H_0/D_0)x(g - 0,6362) \qquad (5)$$

L'équation (5) est comparée au tarif à double entrée établi pour la province (Perron, 1979) :

$$v_m = -16,8426 + 3,088050d - 4,398830h + 0,245404h^2 + 0,026169d^2h \qquad (6)$$

La figure 2A montre que le tarif paramétré est aussi précis que le tarif à double entrée pour la province. Quant au biais (figure 2B), ce dernier sous-estime systématiquement le volume réel, alors que le tarif paramétré présente une tendance à surestimer les stations à faibles volumes et à sous-estimer celles à volumes élevés. Illustrons la sous-estimation et la surestimation par deux exemples: la station riche numéro 9 et la station pauvre numéro 17. La pente de la droite de Hummel est b_m = 107,8096 pour la station riche et b_m = 86,7963 pour la station pauvre. Étant donné que les deux stations ont des rapports H_0/D_0 similaires (0,866 pour la riche et 0,854 pour la pauvre), la prédiction de b_m par H_0/D_0 pour les deux stations se rapprochent: b_m = 95,642 pour la station riche et b_m = 94,305 pour la station pauvre. Ceci entraîne la sous-estimation de la station riche et la surestimation de la station pauvre. Ce phénomène illustre avec éloquence le prix à payer pour alléger l'effort de cubage en sacrifiant la spécificité de chaque peuplement au profit de la prédiction des coefficients par le rapport hauteur sur dhp des arbres dominants. Si nous voulions annuler le biais, nous n'aurions d'autre alternative que d'établir un tarif spécifique à chaque peuplement. Ceci impliquerait l'estimation directe de b_m par l'abattage et le cubage d'un certain nombre d'arbres du peuplement. Pour le choix de ces arbres, rappelons que le tarif de cubage est d'autant meilleur que les extrémités du nuage de points (volume, dhp et hauteur) sont connus. Pratiquement, plutôt que de prendre un échantillon proportionnel (échantillonnage 3P) tel que celui utilisé en Orégon (Hartman, 1977), il suffit de prendre un échantillon constant, c'est-à-dire autant d'arbres dans chaque catégorie de diamètre (Pardé et Bouchon, 1986) . Mais, l'utilisation de la droite de Hummel ouvre la possibilité d'établir une méthodologie simple et efficace pour optimiser l'allocation des arbres échantillonnés par classe de diamètre. Toutefois cette étude est exclue du présent travail.

Abordons à présent l'estimation du volume total. Turnbull et collab. (1965) ont constaté que le rapport entre le volume total (v_t) et le volume marchand présente une tendance décroissante asymptotique par rapport au dhp :

$$R = \frac{v_t}{v_m} = p_1 + p_2\exp(-p_3 d) \qquad (7)$$

Afin d'éviter le problème de limite infinie pour le dhp proche de 9 cm et afin de réduire à deux le nombre de paramètres à estimer, il est possible de procéder aux transformations suivantes:

$$v_t' = v_t + 2(b_m \times 0{,}6362) \qquad (8)$$

$$v_m' = v_m + 2(b_m \times 0{,}6362) \qquad (9)$$

b_m étant la pente de la droite de Hummel (équation 3). L'équation (7) devient:

$$R' = \frac{v_t'}{v_m'} = p_1 + (2 - p_1)\exp(-p_3 d) \qquad (10)$$

Pour l'ensemble des 26 stations, les valeurs estimées de p_1 et p_3 sont:

$$R' = 1{,}027959 + (2 - 1{,}027959)\exp(-0{,}263094 \times d) \tag{11}$$

Utilisé comme base de comparaison, le tarif de la province s'écrit (Tremblay, 1976):

$$v_t = -0{,}69747 + 0{,}44536d - 0{,}02867h - 0{,}05631d^2 + 0{,}00579dh + 0{,}00232d^2h \tag{12}$$

avec v_t en pieds cubes, d en pouces et h en pieds.

La figure 3A montre que le tarif de Turnbull (c'est-à-dire la déduction du volume total à partir du tarif paramétré par H_0/D_0) est beaucoup plus précis que le tarif à double entrée pour la province. Alors que celui-ci sous-estime systématiquement le volume réel, le tarif de Turnbull présente des biais relativement faibles et d'autant plus faibles que le volume de la station est élevé (figure 3B).

ESTIMATION SUR PIED DES VOLUMES EN M^3/HA DES PESSIÈRES NOIRES

Pour cuber un peuplement, la méthode qui vient immédiatement à l'esprit et qui est effectivement la plus utilisée consiste à faire un inventaire, à appliquer aux arbres inventoriés un tarif de cubage d'arbres tel qu'établi auparavant et à en déduire par sommation le volume du peuplement. Dans le cadre d'inventaires couvrant plusieurs centaines d'hectares comme c'est le cas des pessières noires boréales du Québec, il s'avère souvent utile de procéder à des estimations rapides des volumes sur pied en utilisant les caractéristiques dendrométriques simples du peuplement soit la surface terrière et la hauteur dominante ou la hauteur moyenne. Deux volumes sont considérés celui au fin bout et celui à la découpe de 9 cm. Les tarifs sont établis selon le modèle allométrique.

Tous les tarifs basés sur la surface terrière et/ou la hauteur dominante ou moyenne n'ont pratiquement pas de biais (tableau 3). Les erreurs sont légèrement plus élevées pour le volume à la découpe de 9 cm que pour le volume total. En particulier, avec la surface terrière comme unique variable explicative, l'erreur croît de 23 % pour le volume total à 33 % pour le volume à la découpe de 9 cm. L'addition de la hauteur moyenne du peuplement à la surface terrière permet de réduire sensiblement l'erreur à 10 % pour le volume total et à 14 % pour le volume à la découpe de 9 cm. L'addition de la hauteur dominante permet aussi de réduire sensiblement l'erreur à 11 et 12 % respectivement pour les deux volumes. Ce résultat est particulièrement intéressant pour deux raisons. D'une part, la surface terrière peut être rapidement déterminée par un prisme relascopique (Rondeux, 1983) ou la relascope de Bitterlich (1984). D'autre part, la hauteur dominante, en plus d'être peu modifiée par les éclaircies, est un paramètre plus facile à estimer que la hauteur moyenne du peuplement.

La loi de Eichhorn stipule que, indépendamment de l'âge et du site, la production totale en volume ne dépend que de la hauteur atteinte par le peuplement (Assman, 1970). Nous vérifions cette loi en l'exprimant sous forme allométrique. Étant donné que les pessières noires à l'étude ne sont pas aménagées, le volume disparu par mortalité naturelle (ou enlevé en éclaircie) n'est pas connu. De ce fait, la production totale n'est pas connue, seule la production constatée sur pied l'est. Celle-ci exprimée sous forme de volume au fin bout ou à la découpe de 9 cm est statistiquement corrélée à la hauteur dominante ou moyenne (tableau 4). Statistiquement, la vérification de la loi de Eichhorn pour les pessières noires à l'étude est donc positive. Mais l'exactitude absolue des volumes prédits par la loi n'est pas garantie car les erreurs atteignent 40 à 43 % au seuil de 5 % (tableau 3).

ESTIMATION RAPIDE DES VOLUMES SUR PIED DES PESSIÈRES NOIRES VENTILÉS PAR CATÉGORIES DE GROSSEUR

Après avoir établi les tarifs de cubage de peuplements d'épinettes noires de Quévillon basés sur les caractéristiques dendrométriques globales du peuplement, nous étudions à présent la possibilité d'utiliser les mêmes caractéristiques pour prédire la ventilation du volume par catégories de grosseur. Généralement, cette ventilation du volume découle d'inventaire complet (Ung et Trencia, 1989) ou par échantillonnage sur lequel sont appliqués des tarifs de cubage d'arbres adéquats. Mais, dans le contexte de la gestion forestière à grande échelle comme celle des pessières noires boréales, ou de l'appréciation rapide des produits ligneux, il est fort intéressant d'avoir rapidement et à faible coût des chiffres sur le volume sur pied ventilé par catégorie de grosseur.

Le problème consiste donc à étudier le comportement de la distribution diamétrale des pessières noires en fonction des caractéristiques dendrométriques simples du peuplement. Clutter et Bennett (1964) ont été les premiers à utiliser une fonction de densité de probabilité (fonction beta) pour modéliser la distribution diamétrale et à analyser le comportement des paramètres de la fonction par rapport aux caractéristiques du peuplement. Cette approche a depuis gagné beaucoup de popularité (Ung et Bertrand, 1987). Parmi les fonctions mathématiques utilisées, la fonction de Weibull s'avère la plus efficace (Hyink, 1979):

$$f(d) = \frac{c}{b} \left(\frac{d - a}{b}\right)^{c-1} \exp\left[-\left(\frac{d - a}{b}\right)^{c}\right] \qquad (13)$$

où d est le diamètre à 1,30 m en mm, a est le paramètre d'emplacement représentant le diamètre minimal de 90 mm adopté, b en mm représente le paramètre d'échelle et c sans unité représente le paramètre de forme. Les paramètres b et c sont estimés par la méthode du maximum de vraisemblance.

Les corrélations entre les caractéristiques dendrométriques et les paramètres b et c sont présentées au tableau 5. Il existe une relation linéaire entre b et le diamètre moyen du peuplement. Ceci s'explique par le fait que le 63ième percentile de la distribution qui représente le paramètre b (caractéristique intrinsèque de la fonction de Weibull) est fortement relié au diamètre moyen (coefficient de corrélation égal à 0,99). Le paramètre c est bien corrélé au diamètre moyen et encore davantage à la hauteur moyenne du peuplement. À mentionner que, contrairement à Rustagi (1978), le rapport diamètre moyen sur diamètre maximal est faiblement corrélé au paramètre b de la fonction de Weibull.

Étant donné que le diamètre moyen du peuplement est suffisamment lié aux paramètres b et c de la fonction de Weibull, l'idée qui nous vient tout de suite à l'esprit consiste à voir comment se comportent les proportions des volumes par catégories de grosseur en fonction du diamètre moyen du peuplement. Dans un premier temps, les stations étudiées sont réparties en classes de diamètre moyen. Pour chaque classe, le volume à l'hectare de l'ensemble des arbres est ventilé par catégories de grosseur. Les volumes moyens ainsi obtenus sont exprimés en pourcentage du volume global et pondérés par le nombre de tiges de chaque station afin d'augmenter la précision de l'estimation des proportions. Le comportement de celles-ci en fonction du diamètre moyen du peuplement est présenté au tableau 6. Le tableau 7 montre les différences entre les pourcentages moyens calculés pour chacun des niveaux de production et les pourcentages calculés sur l'ensemble des stations indépendamment des niveaux de production. Notons qu'il existe deux niveaux de production parmi les stations étudiées. Nous nous référons à l'annexe pour l'établissement des deux niveaux de production. Les faibles différences montrent la stabilité des pourcentages quels que soient les niveaux de production auxquels appartiennent les peuplements. Cependant, cette indépendance du niveau de production ne signifie pas que celui-ci n'a pas d'effet sur la ventilation des volumes par catégories de grosseur. Il intervient de façon indirecte puisque le diamètre moyen du peuplement est atteint d'autant plus tôt dans la vie du peuplement que la fertilité du niveau de production auquel il appartient est élevée. Comme nous pouvons bien le deviner, l'estimation des volumes par catégories de grosseur nécessite la détermination du diamètre moyen et du volume global à l'hectare. Pour l'estimation de ce dernier, le tarif de cubage du peuplement établi auparavant peut être utilisé, nécessitant la mesure de la hauteur dominante et de la surface terrière.

CONCLUSION

L'utilisation de la valeur moyenne du rapport de la hauteur au diamètre des arbres dominants dans le peuplement permet de rendre les tarifs à simple entrée plus performants que les tarifs à double entrée pour la province. Ce résultat démontre l'intérêt indéniable de régionaliser les tarifs. En effet, en étant à une seule entrée (dhp), ils sont plus pratiques à utiliser et moins coûteux que le tarif à double entrée provincial. Néanmoins, leur utilisation nécessite en plus du dhp de l'arbre cubé, la mesure du dhp et de la hauteur d'un échantillon d'arbres dominants dans le peuplement. Cette mesure ne comporte pas de difficulté particulière, mais il est nécessaire d'établir clairement et simplement la méthodologie d'échantillonnage de ces arbres dominants afin que le tarif soit bien adapté au peuplement. Le tarif à simple entrée paramétré selon la droite de Hummel offre en outre un avantage: grâce à l'utilisation de la pente b_m, la déduction du volume total à partir du volume marchand est particulièrement efficace.

L'application de la loi de Eichhorn, c'est-à-dire l'utilisation exclusive de la hauteur dominante ou hauteur moyenne pour prédire les volumes à l'hectare est certainement rapide, mais son exactitude absolue n'est pas garantie car l'erreur est élevée. Le fait qu'il existe deux niveaux de production parmi les stations étudiées, rend en principe la loi de Eichhorn inapplicable à l'ensemble des stations. Elle ne peut l'être que pour un seul niveau de production. La surface terrière permet d'estimer le volume au fin bout et le volume à la découpe de 9 cm à l'hectare avec 23 et 33 % d'erreur. Avec l'addition de la hauteur dominante, l'erreur diminue à 11 et 12 % respectivement pour les deux volumes. Comportant une erreur relativement faible, l'utilisation conjointe de la surface terrière et de la hauteur dominante est intéressante lorsque seules les caractéristiques globales du peuplement sont connues. Cette utilisation est avantageuse car elle est basée sur des critères simples permettant de couvrir un nombre élevé de situations sur le plan de la productivité des pessières noires boréales. Néanmoins, elle ne présente pas le même intérêt si nous disposons d'un inventaire détaillé du peuplement permettant de déterminer son volume par un tarif de cubage d'arbres.

Le diamètre moyen du peuplement est fortement lié aux paramètres b et c de la fonction de Weibull. Les proportions du volume par catégorie de grosseur sont indépendantes du niveau de production. Cette indépendance du niveau de production ne signifie pas que celui-ci n'a pas d'effet sur la ventilation des volumes par catégorie de grosseur. Il intervient de façon indirecte puisqu'un diamètre moyen du peuplement est atteint d'autant plus tôt dans la vie du peuplement que la fertilité du niveau de production auquel il appartient est élevé.

REMERCIEMENTS

Nos sincères remerciements s'adressent à la compagnie Domtar Inc pour la prise en charge financière et le support technique fourni.

ANNEXE : NIVEAUX DE PRODUCTION

En productivité forestière, la fertilité c'est-à-dire l'interaction entre le potentiel propre du peuplement et celui de la station (sol, climat) est basée sur la croissance en hauteur. Avant de tracer les faisceaux de courbes de la hauteur en fonction de l'âge, il convient de vérifier le niveau de production des stations étudiées. Faute de pouvoir être représenté par le volume total, le niveau de production peut être défini par la surface de plein boisement comme fonction du dhp moyen. La surface terrière de plein boisement s'obtient en corrigeant la surface terrière observée par le taux d'occupation maximal. Celui-ci peut être défini par le rapport:

$$\text{Taux d'occupation maximale} = \frac{\text{Superficie maximale disponible en m}^2\text{/ha}}{\text{Somme des projections horizontales des cimes en m}^2\text{/ha}} \qquad (1)$$

La superfice maximale disponible est:

$$\text{Surface terrière observée} \times \left(\frac{\text{Largeur de cime}}{\text{dhp}}\right)^2 \qquad (2)$$

Parmi les stations étudiées, un groupe de neuf stations présentent une forte relation linéaire entre la largeur de la cime et le dhp:

$$\text{Largeur de cime} = -\,0{,}440256 + 0{,}157638\text{dhp} \qquad R^2=0{,}81 \qquad (3)$$

En outre, ces stations se caractérisent par la prédominance d'éricacées (Kalmia et Ledum) et de sphaigne dans la composition floristique des strates inférieures. Par contre, le reste des stations manifestent en général une prédominance de Pleurozium, une présence plus visible de litière et une moindre importance d'éricacées et de sphaigne. La relation linéaire entre la largeur de cime et le dhp pour ces stations est moins satisfaisante que la précédente:

$$\text{Largeur de cime} = +0{,}413137 + 0{,}115389\text{dhp} \qquad R^2=0{,}41 \qquad (4)$$

La moyenne de la superficie maximale disponible pour les neuf stations est de 3 400 m²/ha alors qu'elle est de 4 700 m²/ha pour le reste des stations. Par opposition au boisement naturel (figure 4A), le boisement maximal permet d'ordonner les stations étudiées en deux niveaux de production (figure 4B).

RÉFÉRENCES

Assmann, E., 1970: The principles of forest yield study. Pergamon Press, 506 p.

Bitterlich, W., 1984: The relascope idea, relative measurements in forestry. Commonwealth Agricultural Bureaux, 242 p.

Clutter, J.L. et Bennett, F.A., 1964: Diameter distributions in old field slash pine plantations. Georgia Forest Research Council Report 13, 9 p.

Dubé, P.A., Chevrette, J.E. et Lamb, P., 1982: Agrométéorologie. Atlas agroclimatique du Québec méridional, données dérivées de la température. Ministère de l'agriculture, des pêcheries et de l'alimentation, Québec.

Freese, F. 1960: Testing accuracy. For. Sci. 6:139-145.

Hartman, G., 1977: Accuracy in pre-sale timber inventory. In: Paul Schmid-Haas ed. World Congress in Oslo, June 20-July 2, 1976 . p. 87-94.

Hummel, F.C., 1955: The volume-basal area line: a study in forest mensuration. Forestry Commission Bulletin no 24, 84 p.

Hyink, D.M., 1979: A generalized method for the projection of diameter distributions applied to uneven-aged forest stands. Purdue University, Ph. D. 160 p.

Pardé, J. et Bouchon, J., 1986: Dendrométrie. 2ième édition. École Nationale du Génie Rural, des Eaux et des Forêts. France. 328 p.

Perron, J-Y., 1979: Tarif de cubage général, volume marchand brut. Ministère de l'Énergie et des Ressources du Québec. Service de l'inventaire forestier. Document ERF-3209-II, 52 p.

Rondeux, J., 1983: La méthode de l'angle critique: une conception particulière de l'échantillonnage appliqué aux inventaires forestiers. Ann. Gembloux, vol. 89, pp. 183-200.

Rowe, J.S., 1972: Les régions forestières du Canada. Service canadien des forêts. Ministère de l'Environnement. Publication no 1300F, 172 p.

Rustagi, K.P., 1978: Predicting stand structure in evenaged stands. In Joran Fries et al Ed. Growth modles for long term forecasting of tomber yields. Publication FWS-1_78. School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, USA, pp. 193-208.

Tremblay, P.H., 1976: Tarifs de cubage généraux. Ministère des Terres et Forêts du Québec. Service de l'inventaire forestier. Cahier 3209.IIg, 44 p.

Turnbull, K.J. et Hoyer, G.E., 1965: Construction and analysis of comprehensive tree-volume tarif tables. State of Washington, Department of Natural Resources, Olympia, Washington, Resource Management Report no 8, 64 p.

Ung, C.-H. et Bertrand, F., 1987: Analyse qualitative des équations différentielles d'un modèle de croissance pour l'érablière à sucre. Canadian Journal Forest Research, vol. 17, pp. 588-593.

Ung, C.-H. et Trencia, J., 1989: Accroissement et qualité des tiges de deux jeunes futaies au Témiscouata. The Forestry Chronicle, vol. 65, no 3, pp. 196-205.

Tableau 1: Valeurs moyennes des paramètres dendrométriques des stations et valeurs estimées de b_m

Placette	Nombre d'arbres	Age moyen ans	Dhp moyen dominant cm	Hauteur moyenne dominante m	Rapport H_0/D_0	Nombre d'obs.	Nombre de tiges à l'ha	Surface terrière m²/ha	b_m
1	5	65	18,9	18,1	0,958	40	1 470	22,77	107,5196
2	5	76	23,5	19,6	0,832	52	780	22,87	97,6737
3	5	68	19,6	17,6	0,898	46	1 470	23,76	98,1077
4	5	124	22,6	20,7	0,919	97	1 360	34,38	102,1166
5	5	67	14,9	13,7	0,924	38	2 240	28,68	96,3905
6	4	80	15,6	16,3	1,051	31	1 410	18,70	121,3177
7	4	68	14,6	15,4	1,053	26	1 810	19,77	129,7064
8	4	134	23,2	20,1	0,866	75	640	16,22	97,4757
9	5	141	23,8	20,6	0,866	94	990	27,98	107,8096
10	5	159	19,5	19,4	0,999	106	870	17,67	111,5409
11	5	99	19,7	17,6	0,892	55	1 460	22,35	94,2079
12	5	124	16,7	16,5	0,992	78	1 140	17,03	103,8507
13	5	93	17,9	16,6	0,932	55	1 420	18,54	101,4463
14	5	124	19,2	18,4	0,957	86	1 370	24,47	99,8120
15	5	126	20,3	18,4	0,907	83	980	16,61	98,9914
16	5	94	19,1	18,3	0,957	52	1 200	25,20	109,1648
17	5	70	12,8	10,9	0,854	35	1 550	14,19	86,7963
18	5	93	22,7	17,6	0,773	52	1 180	22,61	83,6413
19	5	147	19,4	17,8	0,916	96	1 070	18,83	92,2288
20	5	126	21,0	17,8	0,847	65	1 130	18,94	99,0781
21	5	118	13,2	14,2	1,079	56	1 810	19,19	113,6514
22	5	137	19,3	18,2	0,948	74	1 150	20,50	113,4662
23	5	154	19,5	18,9	0,973	96	1 000	18,29	106,7731
24	5	172	16,1	16,1	1,000	68	1 520	20,74	104,0646
25	5	150	13,2	12,7	0,967	41	750	7,86	105,4955
26	5	180	13,0	11,6	0,896	47	1 370	12,69	98,1882

Tableau 2: Coefficients de corrélation entre les paramètres des stations et le coefficient b_m

	Age moyen	Dhp moyen dominant	Hauteur moyenne dominante	H_0/D_0 moyen	b_m
Dhp moyen	0,023	1,000			
Hauteur moyenne	0,088	0,913	1,000		
H_0/D_0 moyen	0,093	-0,560	-0,183	1,000	
b_m	0,001	-0,258	0,071	0,810	1,000

Tableau 3: Erreur au seuil de 5% et biais des tarifs

Volume au fin bout m^3/ha	Erreur %	Biais %
$0{,}615467G^{0{,}943661}H_g^{1{,}001819}$	10	0,19
$0{,}716464G^{0{,}981092}H_o^{0{,}833324}$	11	-0,07
$3{,}270085G^{1{,}263313}$	23	0,20
$0{,}571418H_g^{2{,}116443}$	40	0,89
$0{,}878859H_o^{1{,}806234}$	42	0,49
Volume à la découpe de 9 cm en m^3/ha		
$0{,}190294G^{0{,}984246}H_g^{1{,}363634}$	14	0,49
$0{,}203556G^{1{,}009449}H_o^{1{,}210305}$	12	-0.06
$1{,}854698G^{1{,}419343}$	33	0,50
$0{,}176285H_g^{2{,}526196}$	43	1,36
$0{,}251373H_o^{2{,}211336}$	43	0,60

G surface terrière en m^2/ha, H_o hauteur dominante en mètres, H_g hauteur moyenne du peuplement en mètres

Tableau 4: Analyses de variance pour la relation entre les volumes et les hauteurs

log(volume au fin bout) = a + b.log(hauteur moyenne)

Source de variation	Degré de liberté	Somme des carrés	Carré moyen	Test de F
Régression	1	2,494	2,494	48,531
Résidu	24	1,233	0,051	p=0,0001
Total	25	3,728		

log(volume au fin bout) = a + b.log(hauteur dominante)

Source de variation	Degré de liberté	Somme des carrés	Carré moyen	Test de F
Régression	1	2,297	2,297	38,520
Résidu	24	1,431	0,060	p=0,0001
Total	25	3,728		

log(volume à la découpe de 9 cm) = a + b.log(hauteur moyenne)

Source de variation	Degré de liberté	Somme des carrés	Carré moyen	Test de F
Régression	1	3,553	3,553	59,951
Résidu	24	1,423	0,059	p=0,0001
Total	25	4,976		

log(volume à la découpe de 9 cm) = a + b.log(hauteur dominante)

Source de variation	Degré de liberté	Somme des carrés	Carré moyen	Test de F
Régression	1	3,442	3,442	53,873
Résidu	24	1,534	0,064	p=0,0001
Total	25	4,976		

Tableau 5: Coefficients de corrélation entre les caractéristiques dendrométriques et les paramètres b et c de la fonction de Weibull

	D_0	H_0	H_0/D_0	D_g	H_g	Gm²/ha	N/ha	Âge	Lcime	Dmax	D_g/Dmax	b	c
H_0	0,913	1,000											
H_0/D_0	-0,560	-0,183	1,000										
D_g	0,915	0,893	-0,395	1,000									
H_g	0,781	0,871	-0,103	0,921	1,000								
Gm²/ha	0,506	0,536	-0,136	0,543	0,594	1,000							
N/ha	-0,546	-0,493	0,330	-0,572	-0,419	0,337	1,000						
Age	0,023	0,088	0,093	0,089	-0,037	0,324	-0,470	1,000					
L cime	0,743	0,635	-0,503	0,658	0,569	0,480	-0,238	-0,251	1,000				
Dmax	0,848	0,811	-0,406	0,789	0,678	0,561	-0,392	0,054	0,626	1,000			
D_g/Dmax	-0,197	-0,163	0,140	0,019	0,087	-0,212	-0,124	0,116	-0,167	-0,588	1,000		
b	0,897	0,883	-0,373	0,998	0,931	0,543	-0,566	0,094	0,641	0,765	0,057	1,000	
c	0,591	0,691	-0,056	0,807	0,869	0,506	-0,401	0,156	0,321	0,488	0,270	0,837	1,000

D_o: diamètre moyen dominant; H_o: hauteur moyenne dominante; H_o/D_o: rapport moyen de la hauteur au diamètre dominant; D_g: diamètre moyen du peuplement; H_g: hauteur moyenne du peuplement; Gm^2/ha: surface terrière du peuplement; N/ha: nombre de tiges à l'hectare; Âge: âge moyen; Lcime: largeur de cime; Dmax: diamètre maximum; D_g/Dmax: rapport du diamètre moyen au diamètre maximum; b et c: paramètres de la fonction de Weibull.

Tableau 6. Pourcentages des volumes à l'hectare par catégories de diamètre en fonction du diamètre moyen du peuplement.

Classe de diamètre moyen du peuplement en cm	Catégories de diamètre en cm					Nombre de stations
	9 à 14,9	15 à 19,9	20 à 24,9	25 à 29,9	30 et plus	
9 à 10,9	89,3	10,7	0	0	0	2
11 à 12,9	58,2	31,6	10,2	0	0	7
13 à 14,9	26,1	38,0	18,6	9,7	7,5	11
15 à 16,9	16,9	56,7	19,9	6,5	0	2
17 et plus	7,5	30,0	37,8	21,2	3,5	4

Tableau 7. Différences entre les pourcentages des volumes calculés pour chaque niveau de production et pour l'ensemble des niveaux de production en fonction des catégories de diamètre.

Diamètre moyen du peuplement en cm	Catégories de diamètre en cm					Nombre de stations
	9 à 14,9	15 à 19,9	20 à 24,9	25 à 29,0	30 et plus	
9 à 11,9	Fort niveau -1,1 Faible niveau +1,0	Fort niveau +0,9 Faible niveau -0,8	Fort niveau +0,3 Faible niveau -0,3	- -	- -	2 3
12 à 15	Fort niveau +1,1 Faible niveau -2,3	Fort niveau -0,5 Faible niveau +1,7	Fort niveau -1,5 Faible niveau -2,8	Fort niveau +0,4 Faible niveau -0,7	Fort niveau +0,6 Faible niveau -1,6	10 5
15 et plus	Toutes les stations de diamètre moyen égal ou supérieur à 15 cm appartiennent au fort niveau de production					6

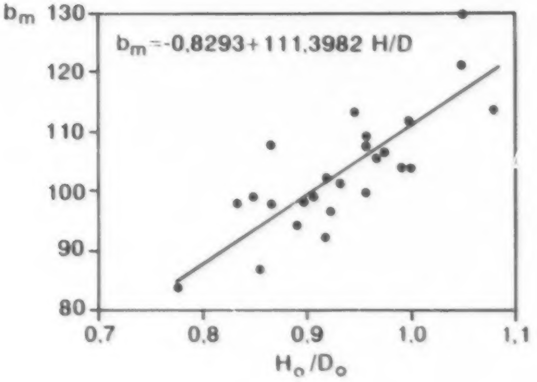

Figure 1. Coefficient b_m en fonction du rapport de la hauteur au dhp dominant : volume marchand

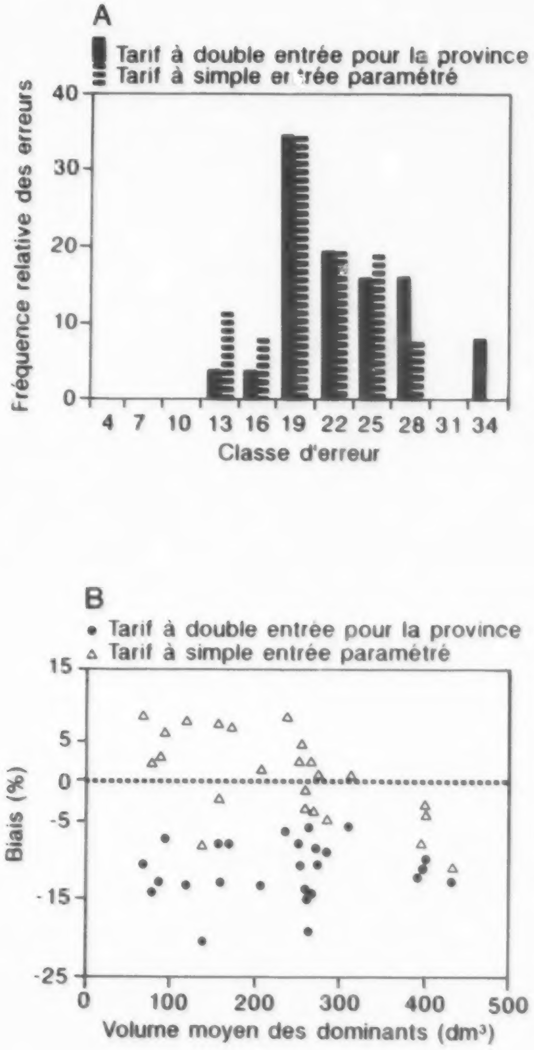

Figure 2. Volume marchand: (A) fréquences relatives des erreurs au seuil 5% ; (B) biais estimé en pourcentage

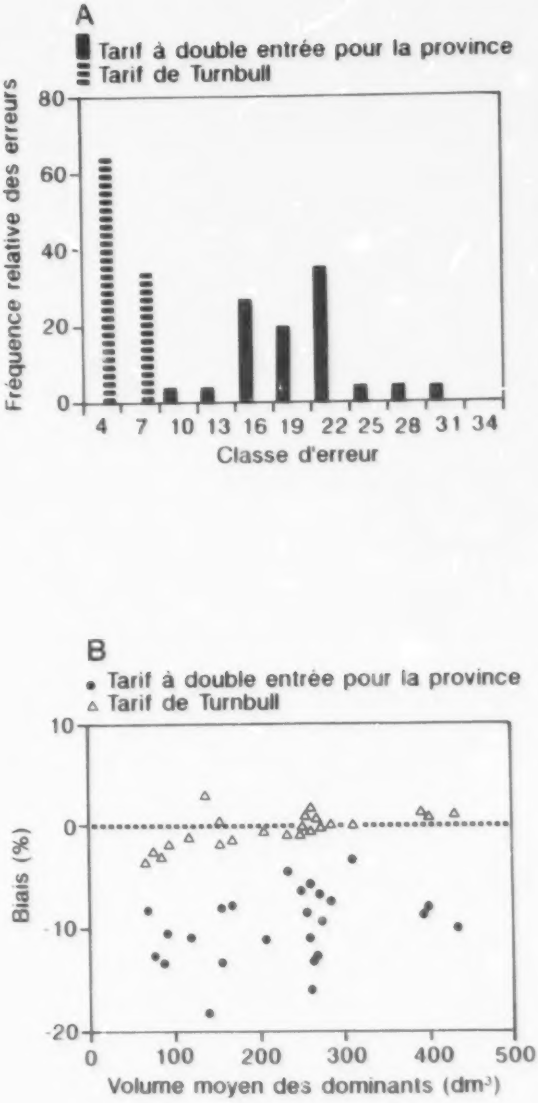

Figure 3. Volume total: (A) fréquences relatives des erreurs au seuil 5% ; (B) biais estimé en pourcentage

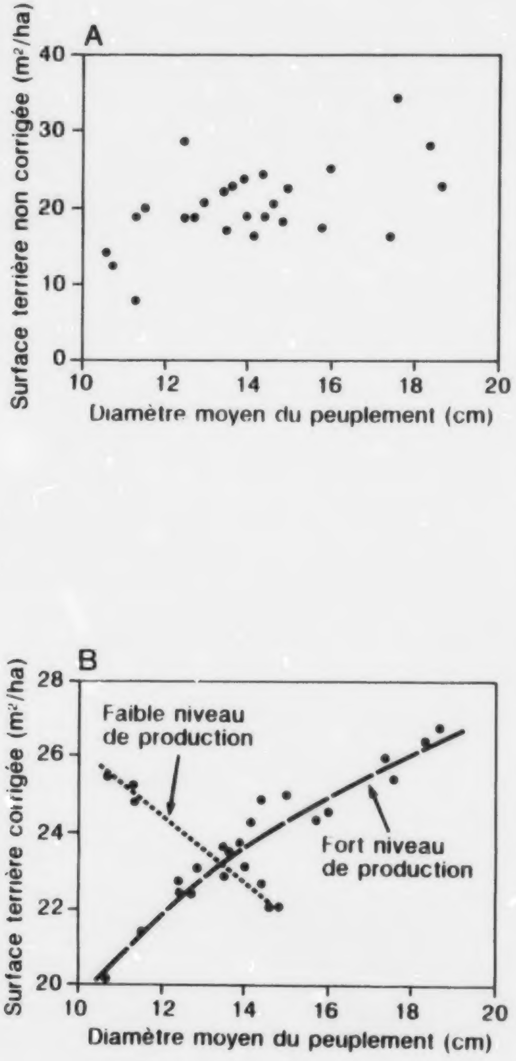

Figure 4. Niveaux de production: (A) boisement naturel;
(B) boisement maximal

MENSURATION OF FOREST BIOMASS: MODERNIZATION OF STANDARD BASE OF FOREST INVENTORY

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SUMMARY

The method of biomass tables designing has been worked out on the base of recurrent multiple regression equations system. This equation system may be presented by the following scheme: harvest biomass data → multiple regression → recurrent regression system → tree or stand biomass table. The method abolishes the necessity of experimental base traditional forest mensuration tables doubling, and regression systems and tables suggested by the author for certain species may be perfectly used in the forest inventory procedure.

Key words: Forest biomass, regression system, recurrent principle.

INTRODUCTION

There were two main traditional trends in the forest biomass structure research: 1) biogeocenotic (ecological), related to the organic matter and energy cycling in the forest phytocenosis, 2) resources trend, that presupposed the forest biomass estimation from the point of view of its utilization. Scientific and technological progress resulted in differentiation and splitting of these trends and it is possible nowadays to add to them at least some applied and fundamental problems:

1) mathematical modelling of forest fires dynamics with the aim of controlling this natural phenomen (Grishin 1981);
2) control and regulation of forest fauna populations and trophic chains (Cooperrider and Behrend 1980);
3) development of management strategy of highly-productive stands growing and adequate regimes of thinnings (Hozumi 1977);
4) development of forest ecological monitoring systems (Biomonitoring... 1987);

5) transition from the traditional ground forest mensuration methods, based on the bole stereometry concept, to the forest resources inventory, based on the remote sensing methods, i.e. using morphological and spectral characteristics of forest canopy (Issledovanije... 1979);

6) estimation of acoustic characteristics of forest canopy, interacting with sound energy by dispersing, reflecting and breaking the sound waves (Martens 1980);

7) research in aerodynamics and wind transparency (openness) of shelterbelts in forest melioration (Kovalev 1975).

The expression of quantity indices of tree and stand biomass with the help of multiple regression seems to be an effective method of the forest biological productivity study. The determining factors of these multiple regressions are the age and environmental ecological characteristics, expressed in tree and stand morphometric indices. In view of a very labour-consuming process of stand biomass estimation on the experimental plots, a very limited available harvest biomass data and a wide variety of traditional forest mensuration standards the aim of our experiments was to work out the correct methods of traditional forest mensuration standards combination with the harvest biomass data. This report with the help of concrete illustrations provides the methodical base for the biomass tables designing and their combination with traditional mensuration standards.

EXPERIMENTAL METHODS

The research sites were located on the southern part of Western Siberia and northern and southern parts of Kazakhstan in 4 geomorphological regions: 1) Western-Siberian lowland, 2) Kazakh low hills to the south from 54° NL, 3) Turgai deflection, i.e. the area of relative immersion between the Urals and Kazakh low hills and 4) Syr-Darya's plain in Central Asia. The forest vegetation in the research areas was presented by the main species: Pinus sylvestris L., Betula pubescens Ehrh. and B. pendula Roth., Populus tremula L., Haloxylon persicum Bge. ex Boiss and H. aphyllum (Minkw.) Iljin. Harvest biomass data was obtained from sample trees according to diameter classes on the experimental plots, situated in different forest types. Number of plots in Pinus, Betula, Populus, Haloxylon persicum and H. aphyllum stands is 63, 45, 32, 75 and 25 respectively. Number of sample trees on the plots is 630, 525, 325, 1885 and 750 respectively. Stands distribution on plots according to species, forest type groups and taxation indices was shown formerly (Usol'tsev 1988, 1989).

Crown biomass was weighed and then foliage percentage was defined either by direct defoliation of young trees or by cutting sprouts with foliage (tree verdure) of older trees with pruning shears (Usol'tsev 1985). Variation index of foliage percentage in tree verdure biomass presents only 2-5%. It was defined by sample branches taken from whorls on vertical crown profile. To calculate foliage and branch biomass on an absolutely dry weight 3 samples were taken from every tree. The data, given for us with a favour by I.S. Krepky on pine root biomass, was used in this study. His data, obtained from 27 sample trees on 11 plots, situated in the same forest types. The stand age varied from 8 to 40 years and site index from Ia to IV.

RESULTS

Tree-level Biomass Tables

In practice we need simplified regression equations and based on them biomass tables which are similar to traditional volume tables with 2 inputs, i.e. tree diameter and tree height. Volume tables are based on the height class scale. This scale can be expressed by the following dependency

$$H = f\,(D, E), \qquad (1)$$

where H - tree height, m.; D - tree diameter at breast height, cm.; E - height class ordinal number (1, 2, 3, etc.).

When designing biomass tables for birch and aspen which are joined with volume tables (Usol'tsev 1985) we can calculate the following regression equation

$$P_i = f\,(H, D), \qquad (2)$$

where P_i - tree component mass, kg. Equations (1) and (2) form a recurrent system: the dependent variable H of the first equation becomes the independent variable in the second equation. The system of dependencies (1) and (2) can be expressed by the following scheme

$$\boxed{\begin{tikzcd}[row sep=large] \text{I.} & P_i = f\,(H, D) \\ \text{II.} \arrow[u] & H = f\,(D, E) \end{tikzcd}} \qquad (3)$$

Equation I is the principal one in system (3). It presents biomass dependency upon determining factors. Equation II is an auxiliary one. It presents the analytical expression of height class scale and serves to combine harvest biomass data with traditional bole volume table. Equation I is valid for the whole approximate height and diameter range and it is independent upon heights and diameters relationship. Equation II is valid only for certain heights and diameters relationship, which corresponds the given scale of height classes, and there may be several scales of this kind. In other words equation I is more general than equation II. One equation I may have several corresponding equations II, that is why any similar recurrent system is multivariant. This property is of great practical importance: it is possible to combine equation I with any height class scale to design the biomass table eventually. Birch and aspen were considered in recurrent regression system (3) and presented in Table 1.

Table 1: Fragment of birch and aspen aboveground biomass table, in freshly-cut condition, kg (I height class)

D, cm	H, m	Biomass components						
		tree verdure		branches		bole		in all
		total	including foliage	total	including bark	total	including bark	
Birch								
8	14,7	2,7	1,7	2,6	1,2	36,2	9,0	41,5
16	19,7	12,6	8,0	22,7	8,6	177,5	35,1	212,8
24	22,0	27,5	17,4	70,6	23,3	414,7	82,5	512,8
32	23,2	46,6	29,6	159,8	47,5	736,9	166,5	943,3
40	23,9	69,1	43,8	287,6	73,0	1114	284,1	1470,7
Aspen								
8	14,7	0,7	0,5	1,7	0,9	34,4	8,2	36,8
16	19,7	6,6	4,6	11,2	5,3	165,9	29,4	183,7
24	22,0	18,9	13,2	44,3	18,2	389,6	61,9	452,8
32	23,2	34,4	24,1	126,5	44,5	707,3	119,5	868,2
40	23,9	49,9	34,9	300,2	95,9	1094	209,0	1444,1

Such equations as I and II in the system (3) are called either independent or simultaneous (Förster and Rönz 1979). These equations are usual when studying complex systems and objects, and their behaviour is described by dependencies combination that connect the principal system characteristics. These systems are called recursive in econometrics. The main condition of their identification is that the total number of dependent and independent variables (without reduplications) should not be less than the number of system equations minus 1 (Tchetyrkin and Kalikhman 1982).

Haloxylon is very close to bush by its morphological structure and one and the same Haloxylon bole diameter value has more wide range of corresponding crown diameter values than birch and aspen have. That is why equation I of system (3) is modified: the third factor, i.e. crown diameter (D_{kp}, m) has been added and breast height diameter has been replaced by root collar diameter (D_o, cm). We get the equation system (4) in result, where P_i - component biomass, kg, i.e. sum total aboveground biomass (P_o), merchantable biomass with the minimum upper branch diameter of 2 cm (P_T) and fodder biomass, i.e. the young sprouts growing up to the height of 1,2 m above ground and accessible to the sheep grazing (P_k).

$$\boxed{\begin{array}{l} \text{I.} \quad P_i = f\,(\,D_o\,,\,H\,,\,D_{kp}\,) \\ \text{II.} \quad H = f\,(\,D_o\,,\,E\,) \end{array}} \qquad (4)$$

The standards for the ground Haloxylon mensuration are obtained by tabulating system (4) (Usol'tsev 1985).

The development of the remote sensing methods of desert forest mensuration resulted in the necessity to modify system (4), i.e. to exclude root collar diameter index from the system, as it is impossible to determine it "from above". Without changing the Haloxylon height class scale we can calculate the following equation in system (4)

$$D_o = f\,(\,D_{kp}\,), \qquad (5)$$

get the recurrent regression system

$$\boxed{\begin{array}{l} \text{I.} \quad P_i = f\,(\,D_{kp}\,,\,H\,) \\ \text{II.} \quad H = f\,(\,D_o\,,\,E\,) \\ \text{III.} \quad D_o = f\,(\,D_{kp}\,) \end{array}} \qquad (6)$$

and the corresponding mensuration standard (Table 2).

Table 2: Fragment of Haloxylon aboveground biomass table according to crown diameter class and height class, kg per tree, in freshly-cut condition

D_{kp}, m	I height class				II height class				III height class			
	H, m	P_o	P_T	P_k	H, m	P_o	P_T	P_k	H, m	P_o	P_T	P_k
						Haloxylon persicum						
0,5	1,6	0,4	0,1	0,1	1,2	0,3	0,1	0,1	0,8	0,2	0,1	0,1
1,5	2,2	4,2	1,6	0,5	1,8	3,9	1,2	0,5	1,4	2,9	0,9	0,6
2,5	2,8	13,3	6,6	1,0	2,3	11,6	5,3	1,1	1,8	9,9	4,1	1,2
3,5	3,4	29,3	17,8	1,6	2,7	24,9	13,8	1,8	2,2	21,2	10,7	2,0
4,5	3,8	51,7	36,1	2,2	3,0	43,8	27,7	2,5	2,4	37,4	21,5	2,8
						Haloxylon aphyllum						
0,5	1,6	0,7	0,1	0,3	1,2	0,5	0,1	0,2	0,8	0,3	0,1	0,2
1,5	2,2	6,0	1,8	0,9	1,8	4,8	1,4	0,9	1,4	3,5	0,9	0,8
2,5	2,8	18,0	6,6	1,8	2,3	14,6	5,0	1,6	1,8	11,6	3,8	1,5
3,5	3,4	38,9	16,2	2,7	2,7	30,5	11,9	2,5	2,2	24,0	8,8	2,3
4,5	3,8	66,7	30,5	3,7	3,0	52,0	22,2	3,4	2,4	41,1	16,4	3,2

The crown biomass indices are more changeable than the bole biomass index, and it is difficult to calculate adequate equations for their determination. When initial studying the stand bioproductivity scientists (Yablokov 1934, Kittredge 1944) already found the close relationship between foliage biomass and bole volume increment. The latter is determined by the bole height and diameter and by the radial increment, and as there is the close height-diameter correlation, we can take into consideration only the last 2 indices, which are easily measured in practice. A number of regression equations (Table 3) is calculated on the base of 320 sample pine trees taken both from homogeneous and ungomogeneous stands of all age classes, growing in different forest sites.

Table 3: Pine biomass dynamics equations characteristic at a tree level

Equation	R^2 for		Equation number
	foliage	branches	
$P_i = f(D, Z^{(5)}_{1,3})$	0,912	0,912	(7)
$P_i = f(D_{0,3}, Z^{(5)}_{0,3})$	0,947	0,947	(8)
$P_i = f(D, Z^{(10)}_{1,3})$	0,897	0,914	(9)
$P_i = f(D_{0,3}, Z^{(10)}_{0,3})$	0,935	0,951	(10)
$P_i = f(D)$	0,758	0,870	(11)
$P_i = f(D_{0,3})$	0,835	0,935	(12)
$P_i = f(D^2H)$	0,669	0,810	(13)
$P_i = f(D^2_{0,3}H)$	0,719	0,865	(14)

In the Table 3: P_i - tree component biomass in dry condition, kg; D and $D_{0,3}$ - bole diameters, breast height and 1/3 bole height correspondingly, cm; $Z^{(5)}_{1,3}$ and $Z^{(10)}_{1,3}$ annual ring average width (mm), breast height during the last 5 and 10 years correspondingly; $Z^{(5)}_{0,3}$ and $Z^{(10)}_{0,3}$ - annual ring average width (mm), 1/3 bole height during the last 5 and 10 years correspondingly.

Equation (7) is tabulated (Table 4). Equations (7)-(10), including both bole diameter and radial increment indices, have the largest coefficient of multiple determination, as all endogenous and exogenous influences are integrally expressed in radial increment. Joining equations (7)-(10) with dendroclimato-

Table 4: Fragment of pine foliage biomass table (kg) in dry condition related to diameter (cm) and average annual ring width at breast height (mm) during the last 5 years

D, cm	Average annual ring width, mm							
	0,05	0,1	0,2	0,4	1,0	1,6	2,2	2,8
8	0,1	0,2	0,4	0,6	1,3	1,8	2,3	2,8
12	0,2	0,4	0,7	1,2	2,4	3,6	4,6	5,5
16	0,3	0,6	1,0	1,8	3,9	5,7	7,4	9,1
20	0,4	0,8	1,4	2,5	5,5	8,2	10,8	13,3
24	0,5	1,0	1,8	3,3	7,4	11,2	14,8	18,2
32	0,8	1,4	2,7	5,0	11,7	17,9	24,0	30,0

logical scales or equations including meteorological factors we can predict all possible crown biomass fluctuations (Rosenberg and Feklistov 1982). Then the regression system can be presented as following

$$\boxed{\begin{array}{l} \text{I.}\quad P_i = f\,(\,D,\, Z_{1,3}\,) = f\,(\,Z_g\,) \\ \uparrow \\ \text{II.}\quad Z_g = a_o + \sum\limits_{i=1}^{m} a_i X_i \end{array}} \qquad (15)$$

where Z_g - cross-sectional area annual increment, per cent to an average long-term value; X_i - meteorological factors values; m - meteorological factors number.

To work out root biomass standards is the most labour-consuming process. The following equations are obtained, which are based on 27 pine root systems harvest data

$$P_1 = 0{,}2280\ A^{-0{,}3622}\ D^{2{,}7226}\ H^{-0{,}4772}\ ;\ R^2 = 0{,}982; \qquad (16)$$

$$P_2 = 0{,}2266\ A^{-0{,}4052}\ D^{2{,}8565}\ H^{-0{,}6942}\ ;\ R^2 = 0{,}980; \qquad (17)$$

where P_1 - total tree roots biomass in dry condition, kg; P_2 - thin (feeding) roots biomass (<1 mm), kg; A - age, years.

Stand-level Biomass Tables

When working out the regression model for stand level we were guided by a conception that aboveground component biomass values and their correlation depend mainly upon stand age and morphological structure special features of different species, if the solar radiation level and precipitation level are praccally the same in the regions under study. And there is no need to calculate separate regression eguations for homogeneous and ungomogeneous stands and to distinguish between seed and coppice ungomogeneous stands, as their difference is mainly morphological. The biomass quantity difference depends upon forest site and origin and is expressed in morphometric indices. These indices should be presented in the maximum range for each determinant to provide the reliability of regression estimates.

The main traditional stand-level standard is yield table. The combination of harvest biomass data with yield tables for pine, birch and aspen stands is realized on the recurrent regression system base

$$\boxed{\begin{array}{ll} \text{I.} & P'_i = f(A,\ G,\ H_{100(50)}) \\ \uparrow & \\ \text{II.} & G = f(A,\ H_{100(50)}) \\ \uparrow & \\ \text{III.} & H_{100(50)} = f(A,\ H_{cp}) \end{array}} \qquad (18)$$

where P'_i - biomass of component i, t. per ha.; $H_{100(50)}$ - site index, expressed in height (m.) at the age of 100 years (pine) and 50 years (birch and aspen) according to the Orlov's site quality scale; G - total basal area, square m. per ha.; H_{cp} - average tree height, m.

Stand biomass is known to be determined by the average tree height, if the stand age and total basal area are constant. The average tree height however is closely correlated with the age. Equation I of system (18) includes therefore the site index instead of the average tree height. To join local site index scales, which serve as the base for yield tables, with Orlov's universal scale the latter is included into system (18) in its analytical expression III. Dependency II is taken from that yield table which is joined with equation I. In Figure 1 curves 1,2,3,4,5 are expressed by equation I with H_{100} =21,5 m.(site index III) and A=20, 40, 60, 80, 100 years respectively and surface 6 -by equation I with constant site index only. Dependency II, taken from the yield table for Kazakhstan natural belt-like pine forests, is presented by curve 7 and the same dependency taken from the yield table for island-like pine forests -by curve 9. When projecting curves 7 and 9 on surface 6, we get two different resulting yield curves 8 and 10 for branch biomass. The number of similar resulting curves is equal to the number of available yield tables. Equation I of system (18) has the coefficient of multiple determination 0,706 for pine branches.

System (18) presupposes the joining of equation I with a yield table only on the base of one index, i.e. total basal area. More adequate joining is provided by recurrent system (19), where total basal area is divided into two constituent parts: average tree diameter (D_{cp}, cm.) and trees number (N, thousand specimens per ha). This is caused by the fact that the P'/D_{cp} curve and the P'/N curve (Figure 2) are not identical in

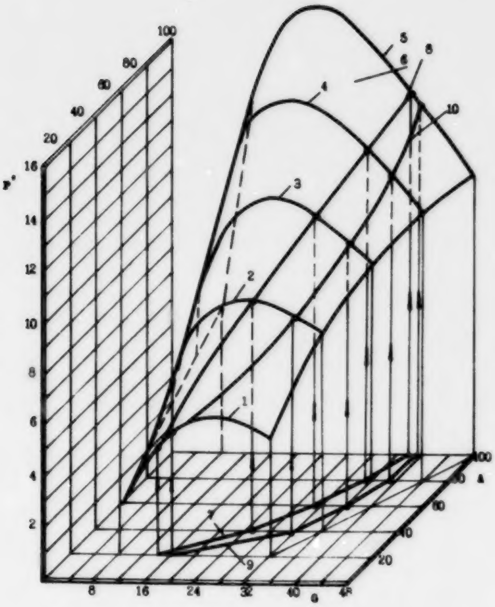

Figure 1: Geometrical expression of recurrent system (18) for pine branches biomass (P', t. per ha). For designation see the text.

$$\boxed{\begin{array}{rl} \text{I.} & P_i' = f\,(A,\ N,\ D_{cp},\ H_{100(50)}) \\ \uparrow & \\ \text{II.} & D_{cp} = f\,(A,\ N,\ H_{100(50)}) \\ \uparrow & \\ \text{III.} & H_{100(50)} = f\,(A,\ H_{cp}) \end{array}} \qquad (19)$$

statics: the former having monotonously rising, the latter - the bell form. Equations I of system (19) have the coefficients of multiple determination for pine 0,988 (bole), 0,850 (branches) and 0,484 (foliage); for birch 0,958; 0,938; 0,799 respectively and for aspen 0,989; 0,978 and 0,969 respectively.

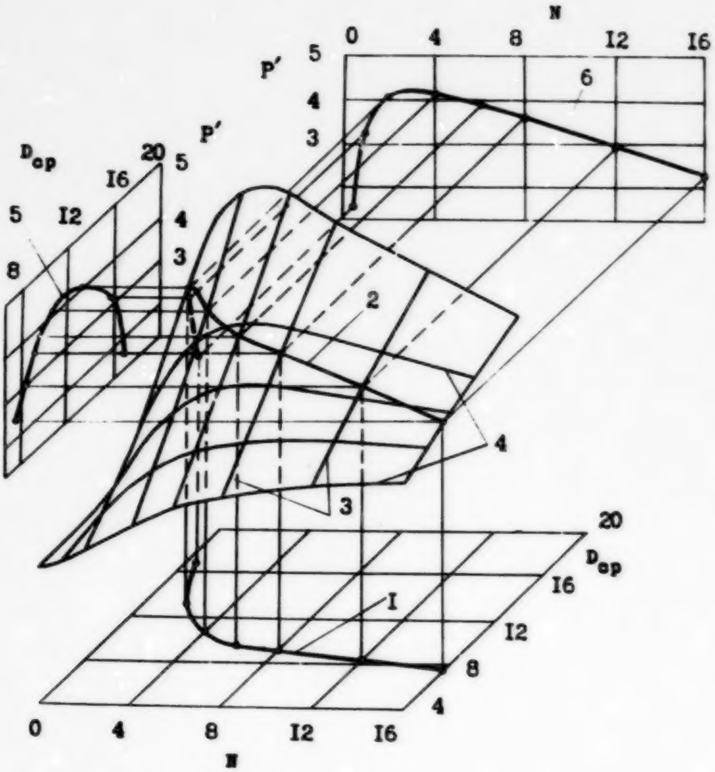

Figure 2: Geometrical expression of recurrent system (19) for birch stand foliage biomass, site index III, age 50 years (P', t. per ha); 1 - curve, expressed by the equation $D_{cp} = f(N)$; 2 - curve 1 projection on the surface, expressed by the equation $P' = f(N, D_{cp})$; 3 - curves corresponding to equal density values; 4 - curves corresponding to equal diameter values; 5 - dependency curve $P' = f(D_{cp})$; 6 - dependency curve $P' = f(N)$.

In its final form equation I is modified by adding such index as bole volume (M, cubic m. per ha). As a result recurrent system (20) is joined with yield table on the base of 3 indices: N, D_{cp} and M.

Thus biomass determinning factors are quite independent, and in view of wide range of ecological and cenotic conditions their multicollinearity may be practically excluded. The combi-

$$\boxed{\begin{array}{ll} \text{I.} & P_i' \,/\, M = f\,(\,A,\ N,\ D_{cp}\,,\ H_{100(50)}\,) \\ \uparrow & \\ \text{II.} & \left\{\begin{array}{l} \text{a)}\ M = f\,(\,A,\ H_{100(50)}\,) \\ \text{b)}\ N = f\,(\,A,\ H_{100(50)}\,) \\ \text{c)}\ D_{cp} = f\,(\,A,\ H_{100(50)}\,) \end{array}\right. \\ \uparrow & \\ \text{III.} & H_{100(50)} = f\,(\,A,\ H_{cp}\,) \end{array}} \qquad (20)$$

nation of dependences II a,b,c presents the analytical expression of interrelations between the main indices of yield table. System (20) provides the combination of its equation I with any yield table. Recurrent principle reflects the most important characteristic of suggested approach - the multivariant interdependence of the factors, that provides the flexibility and generalization of regression systems, simulating stand biomass dynamics. If dependences II a,b,c in system (20) are obtained on the tree-level simulation of growth and mortality of stand trees (Schneider und Kreysa 1981) or are taken from computer forest inventory data bank, then system (20) will be multivariant as concerned every stand, rather than every yield table.

In view of a very limited available root biomass harvest data the combination of harvest data with yield tables is carried out on the average tree base. In this case equations (16) and (17) are considered, modified as

$$P_i = P_i'/N = f\,(\,A,\ H_{cp},\ D_{cp}\,)$$

and introduced into recurrent system (21):

$$\boxed{\begin{array}{ll} \text{I.} & P_i' / \, N = f\,(\,A,\ H_{cp},\ D_{cp}\,) \\ \uparrow & \\ \text{II.} & \left\{\begin{array}{l} \text{a)}\ N = f\,(\,A,\ H_{100(50)}\,) \\ \text{b)}\ H_{cp} = f\,(\,A,\ H_{100(50)}\,) \\ \text{c)}\ D_{cp} = f\,(\,A,\ H_{100(50)}\,) \end{array}\right. \\ \uparrow & \\ \text{III.} & H_{100(50)} = f\,(\,A,\ H_{cp}\,) \end{array}} \qquad (21)$$

Dependences II a,b,c in system (21) are taken from yield tables as well. Pine (Table 5) was considered in recurrent regression systems (20) and (21).

Another principle is presented in recurrent system (22) used for designing Haloxylon biomass tables, where G_{kp} - actual sum total of crown cross-section, ths square m. per ha.; G_{kp}^{H} - normal (for relative stand density 1,0, according to Zhirin 1966) sum total of crown cross-section, ths square m. per ha.;

$$\boxed{\begin{array}{ll} \text{I.} & P_i'/G_{kp} = f(H_{cp}) \\ \uparrow & \\ \text{II.} & G_{kp}^{H} = f(H_{cp}) \\ \uparrow & \\ \text{III.} & H_{cp} = f(D_{kp}^{cp}, B) \end{array}} \qquad (22)$$

D_{kp}^{cp} - average crown diameter, m.; P_i'/G_{kp} - stand form height (according to aboveground biomass), t. per ths square m.

Haloxylon biomass tables are made eventually with stand density 1,0 (Table 6). Since P_i'/G_{kp} ratio in the system (22) is independent of stand density, biomass values in Table 6 may be corrected for any stand density by trivial reduction procedure.

Table 5: Fragment of biological productivity table for growing part of pine stands; the harvest data are combined with generalized yield table (Zagreev 1974)

A, yr	M, cubic m.per ha.	Component biomass, t. per ha.							
		in dry condition						in fresh condition	
		bole	branches	foliage	roots		in all	crown	including tree verdure
					total	including <1 mm.			
		Site index II							
20	177	62	12,4	12,5	52,9	39,0	139,8	48	37
40	441	151	20,2	10,4	67,8	42,0	249,4	73	30
60	658	231	30,1	10,0	89,5	48,9	360,6	120	29
80	800	290	34,8	9,4	96,0	47,7	430,2	141	28
100	886	329	35,8	8,9	93,4	43,0	467,1	137	28
120	941	354	35,0	8,8	87,8	38,0	485,6	120	28

CONCLUSIONS

The analysis of current trends in forest biological productivity potential estimation shows that our demands to the knowledge of qualitative and quantitative forest biomass characteristics became much higher. It resulted in necessity of new methods of forest biomass growth and structure research, which make it possible to estimate the multifactorial influence of ontogenetic, indirect ecological (i.e. morphological) and other factors on the forest biomass structure.

Table 6: Haloxylon aboveground biomass P'_o(t. per ha.) for stand density 1,0 related to average crown diameter and site index, in freshly-cut condition

D^{cp}_{kp}, m.	Site index								
	I			II			III		
	H_{cp}, m.	G^{H}_{kp}, ths square m. per ha.	P'_o, t. per ha.	H_{cp}, m.	G^{H}_{kp}, ths square m. per ha.	P'_o, t. per ha.	H_{cp}, m.	G^{H}_{kp}, ths square m. per ha.	P'_o, t. per ha.
Haloxylon persicum									
0,8	1,2	1,8	3,1	1,0	1,6	2,4	0,9	1,5	2,1
1,2	1,6	2,3	5,2	1,4	2,0	4,1	1,3	1,9	3,6
1,6	2,0	2,8	7,6	1,7	2,5	6,0	1,6	2,3	5,2
2,0	2,3	3,2	10,3	2,0	2,9	8,1	1,8	2,7	7,0
2,4	2,6	3,7	13,2	2,3	3,2	10,3	2,1	3,0	8,9
2,8	3,0	4,1	16,2	2,6	3,6	12,7	2,4	3,4	11,0
3,2	3,3	4,5	19,5	2,8	4,0	15,2	2,6	3,7	13,2
Haloxylon aphyllum									
0,8	1,2	1,9	3,8	1,0	1,6	2,9	0,9	1,5	2,4
1,2	1,6	2,3	5,9	1,3	2,0	4,4	1,2	1,8	3,7
1,6	1,9	2,7	8,1	1,6	2,3	6,0	1,4	2,1	5,1
2,0	2,2	3,1	10,4	1,8	2,6	7,7	1,7	2,4	6,5
2,4	2,4	3,4	12,7	2,0	2,9	9,5	1,9	2,7	7,9
2,8	2,7	3,7	15,2	2,2	3,2	11,2	2,0	2,9	9,4
3,2	2,9	4,0	17,6	2,4	3,4	13,0	2,2	3,1	10,9

The above analysed recurrent principle of designing biomass tables presupposes the necessity of seeking stands located in all forest sites and with all possible mensuration indices with the aim of working out biomass equations describing all possible ecological stand conditions in statics. The process of obtaining biomass experimental base is a very labour-consuming one, but this method makes it possible to use the harvest data minimum without doubling of "numbers cemeteries" generated when working out traditional mensuration standards.

The suggested recurrent conception is universal. The method of trees and stands biological productivity description by means of recurrent regression equations systems was the main instrument that gave important practical results. This method may be used for the development of the phenomenological forest productivity theory.

LITERATURE CITED

Biomonitoring lesnykh ekosistem, 1987: Materialy Mezhdunarodnoi shkoly-seminara. Vil′nyus, *LitSKhA*, 265 s. (in Russian).

Cooperrider, A.Y. and Behrend, D.F., 1980: Simulation of forest dynamics and deer browse production. *Journal of Forestry*, vol. 78, no. 2, pp. 85-88.

Förster, E. and Rönz, B., 1979: Methoden der Korrelations- und Regressionsanalyse: Ein Leitfaden für Ökonomen. Berlin, *Verlag Die Wirtschaft*, 302 S.

Grishin, A.M., 1981: Matematicheskie modeli lesnykh pozharov. Tomsk, *Tomskii universitet*, 277 s. (in Russian).

Hozumi, K., 1977: Ecological and mathematical considerations on self-thinning in even-aged pure stands. *The Botanical Magazine Tokyo*, vol. 90, no. 1019, pp. 165-179.

Issledovanie tayozhnykh landshaftov distantsionnymi metodami, 1979: Novosibirsk, *Nauka*, s. 75-88 (in Russian).

Kittredge,J.I.,1944: Estimation of amount of foliage of trees and stands.*Journal of Forestry*, vol.42, no.11, pp.905-912.

Kovalev, Yu.L., 1975: Arkhitektura dereva. *Znanie-sila*, no. 11, s. 36-38 (in Russian).

Martens, M.I.M.,1980: Foliage as a low-pass filter:experiments with model forests in an anechoic chamber. *Journal of Acoustic Society of America*, vol. 67, no. 1, pp. 66-72.

Rodin, L.E., Remezov, N.P., Bazilevich, N.L.,1968: Metodicheskie ukazaniya k izucheniyu dinamiki i biologicheskogo krugovorota v fitotsenozakh. L., *Nauka*, 144 s. (in Russian).

Rosenberg, G.S. and Feklistov, P.A., 1982: Prognozirovanie godichnogo prirosta drevesnykh rastenii metodami samoorganizatsii. *Ekologiya*, no. 4, s. 43-51 (in Russian).

Schneider, T.W. und Kreysa, J., 1981: Dynamische Wachstums- und Ertragsmodelle für die Douglasie und die Kiefer. *Mitteilungen der Bundesforschungsanstalt für Forst- und Holzwirtschaft*, no. 135, S. 1-137.

Tchetyrkin, E.M. and Kalikhman, I.L., 1982: Veroyatnost′ i statistika. Moskva,*Finansy i statistika*,319 s.(in Russian).

Usol′tsev, V.A., 1985: Modelirovanie struktury i dinamiki fitomassy drevostoev. Krasnoyarsk, *Krasnoyarskii universitet*, 191 s. (in Russian).

Usol′tsev, V.A., 1988: Rost i struktura fitomassy drevostoev. Novosibirsk, *Nauka*, 253 s. (in Russian).

Usol′tsev, V.A., 1989: Recurrent regression system as a base for tree and stand biomass tables. Pages 217-245 *in*: Harvesting and Utilization of Tree Foliage. *IUFRO Project Group P3.05-00 Meeting*, Riga, 280 p.

Yablokov, A.S., 1934: Kul′tura listvennitsy i ukhod za nasazhdeniyami. Moskva, *Goslesbumizdat*, 128 s. (in Russian).

Zagreev, V.V., 1974: Vseobschie tablitsy khoda rosta normal′nykh sosnovykh nasazhdenii. S. 67-101 *in*: Sovremennoe lesoustroistvo i taksatsiya lesa. Moskva, *VNIILM*, 421s.(in Rus.).

Zhirin, V.M., 1966: Nekotorye voprosy taksatsii pustynnykh lesov. S. 42-48 *in*: Materialy nauchno-tekhnicheskoi konferentsii 1966 g. Leningrad, *LTA*, vypusk 2 (in Russian).

January 31, 1990

APPLICATION OF PERMANENT AERIAL PHOTOGRAPHIC SAMPLES FOR THE MANAGEMENT OF FOREST ENTERPRISES AND STAND SURVEYS

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The German forest survey methods are traditionally related to single stands. According to that the registration of forest conditions were carried out for single stands as well. Planning and supervising of the felling quantities are deduced from the stand development assumed in the German yield tables.

Because of both the gradual transition towards long-term regeneration methods, the cultivation of mixed stands, a chosen-tree-system and an increasing demand for information concerning the physical conditions and the development of forest stands the traditional survey methods are as yet not able to supply the desired data in an adequate manner. In addition to that the evolving stratified and uneven stands are more and more withdrawing from the stand development according to the yield tables.

For that reason permanent sampling with concentric sample areas has been introduced for the inventory of "naturally" treated forests in the northern part of Germany (Lower Saxony) since 1981.

This inventory method, deduced from the Swiss continuous inventory system with permanent sample plots, is at present merely used for the control of aggregated stand survey data at the forest enterprise level.

Since aerial photographs (1:10000) exist for almost all forest enterprises (a result of the registration of forest damages caused by air pollution) the question has been put whether the information possibly gained from that medium could be used for a combined forest survey system.

Creating a double-sampling inventory system using permanent photographic and ground samples might be improve the efficiency of the actual lower saxony sampling method.

Examplarily the forest district "Seesen", a forest enterprise located at the north-western border of the harcynian highlands, has been chosen to approve different techniques of double-sampling for timber estimating at the level of both the total enterprise and the single stand.

DETERMINING THE VOLUME OF LOGS IN AUSTRALIAN HARDWOOD TREES USING CENTROID SAMPLING

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Centroid sampling was tested on 18 sample trees of mature *Flindersia brayleyana* and 124 sample trees, all but 22 mature, of five species of *Eucalyptus*. Diameter over bark at breast height (DBHOB) ranged from 4-186 cm, total height from 7-70 m and height of the main bole (nominally to crown break) from 3-45 m. A total of 1288 measurements of diameter under bark (DUB) along the bole of the 142 trees was available for analysis, the average distance between measurement points being 2.3 ± 0.96 m.

Volumes of the main bole of each tree and of logs (length approx. 6 m) derived from it were estimated using both Huber's formula and centroid sampling, and these estimates were compared with 'true' volume derived by summing the volumes derived using Smalian's formula of all the short sections comprising the main bole and each log respectively. The DUBs at the mid-point of the main bole or log (for use in Huber's formula) and at the centroid (for centroid sampling) were derived by linear interpolation between the DUBs at the nearest points of measurement on each side of the defined point.

The mean error of the centroid estimate of volume of the main bole was not significant for *Euc. sieberi* and *Euc. diversicolor* and was less than that of Huber for all species except *Euc. regnans*. When all species were combined, the centroid estimate was clearly superior, its mean error (-2%) being just significant (p=0.046). For log sections approximately 6 m long, the mean error of the centroid estimate was significant for the 3-9 m section only whereas that of Huber was significant in the butt 6 m, and at 3-9 m and 6-12 m. The centroid estimate was clearly superior in the lower bole.

RESOURCE ALLOCATION CONCEPTS IN MULTI-PURPOSE FOREST MANAGEMENT

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Public reactions to forest management activities are becoming more important for forest managers to understand and predict. The public has gained interest and sometimes insisted on delaying plans and projects when they are apprehensive about the ecological, visual and social welfare effects caused by such forest activities. This paper is devoted to the forested land management planning research and development process used for allocating each stand for different purposes. The target of this approach is timber production adjustment and soil conservation, watershed management, recreation, scenic resources and so on.

OPTIMAL MANAGEMENT STRATEGY DEVELOPMENT FOR SCARLET AND BLACK OAK USING LINEAR PROGRAMMING

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FDC : 624: 176.1 Quercus L.--015.5

Optimal management strategies were developed for a natural even-aged 240-acre forest of scarlet (Quercus coccinea Muechh.) and black oak (Quercus velutina Lam.) utilizing linear programming. Lumber yield data, collected from long-term thinning research plots composed of even-aged stands, were assimilated with other information and used in conjunction with a system of models to develop management strategies. Linear programming was used to explore the interactive effects of timing, frequency, and intensity of thinning upon development of four hypothetical forest stands over a 33-year period. This permitted the simultaneous evaluation of numerous management strategies for each stand under various resource constraints and landowner objectives. The linear model selected the stands for harvest, the acres to be treated, and identified the management regime each stand should receive over time in order to maximize net present worth.

NEW DIRECTIONS IN MATHEMATICAL PROGRAMMING APPLIED TO FOREST MANAGEMENT PLANNING

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SUMMARY

Most research to date on the use of mathematical programming in forest management planning has emphasized the planning of commercial timber harvests, with other resource values usually being included as secondary considerations. Furthermore, planning models have traditionally lacked spatial integrity, with the result that model outputs tend to overestimate forest productivity, especially in the context of multiresource management. Forest planning systems in the 1990s and beyond will require the use of sophisticated computer technology to integrate mathematical programming with geographic information systems, multiresource simulation models, and expert systems in a way that permits forest managers to visualize the multiresource tradeoffs associated with management decisions. These future decision support systems must be easier to use, more intuitive, and yet they must also help the forest manager guard against incorrect decisions. Finally, the decision support systems must also serve an educational function, so that they can be used to help inform the public and also to help obtain public input that can be used to improve management decisions.

Keywords: Linear programming, integer programming, spatial constraints, geographic information systems, multiresource tradeoffs

BACKGROUND -- MATHEMATICAL PROGRAMMING IN FOREST MANAGEMENT PLANNING

Forest management planning has long been considered a complex and difficult science (e.g., see Faustmann 1849). By its very nature, forest management involves the interplay of many resources, even in situations when a single resource, such as timber, is dominant in the mind of the forest manager. The decision to cut a tree, or to let it grow, affects many things besides the tree itself. While this is true for private forests, in the context of public forest management the situation is even more difficult; public foresters may be required by law to consider the desires of the lay public, as well as those of interest groups, professional foresters, and specialists such as wildlife managers, landscape architects, and soil scientists, before making decisions about the management of forest areas[1]. In addition, public foresters may be required to consider the potential long-term cumulative effects[2] associated with any kind of forest-management activity, whether it involves timber harvesting, road construction, the development of recreation areas, or simply doing nothing. Accomplishing this in a cost-effective way necessitates the use of comprehensive models not only for initial planning but also for monitoring the effects of management activities.

Forest Planning Models

Because of its inherent complexity, and its importance to everyday forestry, efforts have been made for more than a century to develop mathematical models that could be used to improve forest management planning. The "Faustmann Formula" (Faustmann 1849) and the "formula regulation" models derived from it and from several other theoretical constructs are early examples of such modeling efforts. Shortly after World War II, both the electronic computer and the emerging discipline of management science contributed much to forest management planning; during the 1960s and 1970s in particular considerable effort was devoted to the development of planning methodologies based mostly on the model of linear programming. These models included Timber RAM (Navon 1971) and MAX-MILLION (Ware and Clutter 1971), both of which have been extensively used in the United States, and several less well-known but nevertheless important predecessors such as the models of Leak (1964), Loucks (1964), Kidd et al. (1966), and Nautiyal and Pearse (1967). Following an important review and synthesis of these modeling efforts by Johnson and Scheurman (1977), the MUSYC model of Johnson and Jones (1979) was developed in an effort to deal more effectively with site-specific, multiple-use objectives. This model was later revised thoroughly and became the now-famous FORPLAN model (Stuart and Johnson 1985) that has been used extensively by the USDA Forest Service in the development of strategic management plans for the national forests.

Spatial Integrity in Planning Models

Linear programming (LP) models such as Timber RAM and FORPLAN are subject to the inherent limitations of linear programming, including the assumption of divisibility. This means that such models cannot guarantee, and usually do not produce, integer solutions. Integer solutions are often essential in operational planning models (as opposed to strategic planning models) where, for instance, an entire timber stand or similar planning unit must be treated in one particular way and is not to be subdivided. Early efforts to utilize linear programming for detailed planning of such situations (e.g., Thompson et al. 1973), while unsuccessful because of the limitations of LP itself, nevertheless laid the foundation for recognizing the concept of *spatial integrity* in forest management planning as outlined by Dykstra (1980).

Early attempts to explicitly recognize and accommodate the need for spatial integrity in forest planning models include the original 0-1 integer programming work of Balas (1963), a land use planning model by Nautiyal et al. (1975), the CASCADE model of Dykstra and Riggs (1977), the Unit Planning model of Burkhart et al. (1976), and an integrated silviculture/transportation model of Weintraub and Navon (1976).

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[1] For example, the USDA Forest Service is required, under the terms of the National Forest Management Act of 1976 (P.L. 94-588, 90 Stat. 2949) to obtain and consider the views of the lay public before making decisions about forest planning or forest operations on the national forests of the United States.

[2] This type of requirement is imposed on managers of the U.S. national forests, for example, by the National Environmental Policy Act of 1969 (P.L. 91-190, 83 Stat. 852).

During the 1980s, considerable effort has been directed toward the problem of maintaining spatial integrity in forest planning models. This work has proceeded from two complementary but independent approaches: the formulation of mathematical programming models that include *spatial constraints*, and the integration of *geographic information systems* into the forest planning methdodology.

Spatial Constraints

Constraints are used to define the feasible solution space of mathematical programming problems. *Spatial constraints* are formulated to require that the physical juxtaposition of timber stands (or road locations, or watersheds, or cutting units, etc.) is explicitly recognized. Much of the work on spatial constraints has been motivated by the need to schedule the harvest of adjacent cutting units in such a way that negative impacts on wildlife (especially from clearcutting) are minimized. Typically this has been interpreted to mean that a particular cutting unit can only be harvested if the trees on all adjacent units are older than a specified age.

Published work relating to the formulation and solution of forest planning models that incorporate spatial constraints includes that of Mealey et al. (1982), Hokans (1983), Bare et al. (1984), Jones et al. (1986), Kirby et al. (1986), Meneghin et al. (1988), Gross (1989), Gross and Dykstra (1989), and O'Hara et al. (1989). Of these, only three--the methodologies developed by Hokans (1983), Kirby et al. (1986), and O'Hara et al. (1989)--appear to offer promise for real-world forest planning. Mealey et al. (1982) draw incorrect conclusions as a result of erroneous initial assumptions. The work of Bare et al. (1984) was preliminary and led to the subsequent developments by O'Hara et al. (1989). The model of Jones et al. (1986) is correctly formulated but makes no attempt to solve the harvest scheduling portion of the problem to an integer solution. The research by Meneghin et al. (1988) is both correct and interesting, but because of difficulties in finding integer solutions is not likely to prove useful in the long run. Finally, the work reported by Gross (1989) and by Gross and Dykstra (1989) comprises primarily a set of mathematical proofs that clarify certain principles associated with the use of spatial constraints in forest planning models and also illustrates the computational difficulties associated with finding exact (integer) solutions to models incorporating spatial constraints.

The three "promising" approaches for incorporating spatial constraints all involve the use of heuristic algorithms, rather than exact integer-programming algorithms, for problems of realistic size. The methodology of Hokans (1983) uses a discriminant function to define a spatially feasible harvest schedule for a subunit of the forest; the focus of this method is on ensuring that policy limits on clearcut size are not exceeded. Kirby et al. (1986) use a network-based heuristic, which is a natural consequence of their joint transportation/harvest-scheduling formulation. O'Hara et al. (1989) utilize a random-search heuristic to generate combinations of units for harvest over the desired planning horizon in such a way that both harvest flow and spatial constraints are met.

Geographic Information Systems

Although geographic information systems (GIS) have been available since the mid-1970s, their modeling capabilities have only recently reached a level of sophistication sufficient to permit integrating them into forest planning methodologies. Geographic information systems typically offer three functions: entry and reconciliation of geographically referenced data, spatial modeling (which includes both direct cartographic analysis and also the manipulation and analysis of the geographically referenced data, usually by means of an integrated relational database system), and the preparation of both tabular and map-based outputs. The use of GIS in forest management planning is a subject in its own right; our interest here is the potential integration of GIS with forest planning methodologies incorporating mathematical programming as a primary tool.

Nearly all schools of forestry in the United States and Canada are now utilizing GIS in research and are teaching courses in GIS technologies. However, there have been few reported efforts to integrate GIS together with mathematical programming into comprehensive forest planning methodologies. A notable exception is the use of GIS in the TEAMS model originated by D. B. Wood and W. W. Covington at Northern Arizona University (Covington et al. 1988, Wood et al. 1989, Fox et al. 1989). This forest planning model links a linear programming harvest scheduler with a GIS so that the spatial context of the harvest schedule can be visualized by the analyst or decisionmaker. In the current version of TEAMS, the concept of the mathematical optimum is de-emphasized, with the primary emphasis being placed on the achievement of a satisfactory harvest schedule that also provides satisfactory spatial feasibility as defined for a variety of resource values which may be selected by the forest manager.

MULTIRESOURCE FOREST MANAGEMENT

The vegetative and structural patterns in a forest change over time in response to many dynamic influences. Although the landforms themselves change little in human time, the spatial character of the forest can be altered quite rapidly as a result of management decisions, demographics (witness the clearing of tropical rainforests for agriculture), or random events such as windstorms and wildfires. One objective of forest planning, then, is to manage the constantly changing spatial character of the forest to provide for an optimal total value of all resources over the long run. Because the spatial character of the forest is not static, and because the relative values society places on various resources may change over time, a forest plan is like an arrow aimed at a moving target; the plan itself must be in constant motion in order to keep pace with, or anticipate, the target.

Laws or policies pertaining to the management of forests, whether public or private, inevitably lead to consideration of tradeoffs among values associated with various forest resources. As an illustration of the kinds of tradeoffs inherent in forest management planning, Figure 1 shows some potential relationships between basal area, a common measure of the density at which trees are growing in a forest (typically expressed in m^3/ha), and several representative resource values. Some resource values, such as cover for wildlife, may be *directly proportional* to basal area; an increase in basal area provides an increase in cover. Other values, such as water yield or the production of forage plants, may be *inversely proportional* to basal area; an increase in basal area results in less water yield and reduced herbage production. Still other values, such as timber volume or scenic beauty, may be *nonlinearly proportional* to basal area. Such an effect would imply, for example, that the basal area to maximize timber volume lies somewhere between the feasible minimum and feasible maximum basal-area values for the forest.

Multiresource forest management requires explicit consideration of tradeoffs among various resource values. In the United States, managers of federal forest lands are for the most part required by law to do multiresource management (an exception is in wilderness areas which have been established by Congress for special treatment). This means that the managers of federal forest lands must establish tradeoff functions similar to those shown in Figure 1, and that furthermore both the functions and the resource values considered must be established through public involvement. Practicing multiresource management is inherently difficult, and in my view it is probably impossible without the assistance of decision support systems designed specifically to relieve managers of at least some of the burden of information processing relating to the kinds of multiresource tradeoff analyses suggested in Figure 1.

Decision Support Systems

As outlined by Bracken and Webster (1989), an information system can be thought of as a decision support system if it has three distinguishing features: (1) it will assist decisionmakers in

```
             |--Increasing basal area of trees----------------->|

Timber       |--Increasing volume----------------->|<-----------|

             |<-----------------------------Increasing yield----|
Water        |--Increasing quality------------------------>|<---|
             |--Decreasing storm flows ------------------------>|

Soils        |--Decreasing erosion and sedimentation----------->|

Aesthetics   |--Increasing scenic beauty---->|<-----------------|

Forage       |<------Increasing production of forage plants-----|

Cover        |--Increasing thermal & hiding cover-------------->|

Openings     |--Increasing "edge"---->|<------------------------|
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Figure 1: Some tradeoffs inherent in forest management, as measured against the basal area of trees in the forest.

solving "ill-structured" problems by supporting the exploration of the various branches of a decision tree and allowing the decisionmaker to pose a series of "what-if" questions; (2) it supports a powerful, high-level language interface for the expression of problems; and (3) it incorporates analytical models which provide the capacity to generate complex information products. I would submit that nearly all of the research to date on the application of mathematical programming to forest management falls into Bracken and Webster's category (3), and that little work has been done on the requirements of categories (1) and (2). The TEAMS model developed at Northern Arizona University comes perhaps closest of any model I know about to meeting the requirements of a decision support system for multiresource forest management planning. However, my judgment is that TEAMS does not yet provide sufficient assistance to decisionmakers in Bracken and Webster's category (1), and falls far short of the requirement of category (2).

FUTURE DECISION SUPPORT NEEDS

There is no question but that forest managers, especially those attempting multiresource forest management, need improved decision support tools. Multiresource forest management is by definition an interdisciplinary activity. Few forest managers, in this age of specialization, have the expertise to fully evaluate the enormous range of potential multiresource impacts associated with forest management activities. The development that represents perhaps the greatest single advancement in bringing the practice of multiresource forest management closer to reality is the computer, and especially the personal computer. The task of scientists involved in research relating to forest management planning is to merge the increasingly powerful capabilities of personal computers with decision support systems that provide a full range of capabilities to forest managers. In the context of the categories outlined by Bracken and Webster (1969), decision support systems for forest management should:

1. Include a geographic information system, coupled with a multiresource simulation model and an expert system to help guide the exploration of "ill-structured" problems associated with multiresource forest management planning.

2. Provide a menu-driven interface through which the forest manager can express problem situations in an intuitive yet precise way.

3. Incorporate spatially consistent mathematical programming models (which are likely to use heuristic solution algorithms) to solve site-specific allocation problems associated with multiresource management planning.

Perhaps the most difficult part of developing the "ideal" decision support system for multiresource forest management is the task of integrating the geographic information system with the mathematical programming software (possibly through an expert system) in a way that facilitates visualization of multiresource tradeoffs by the forest manager. The decision support system would also optimally serve an educational function, so that it could be used to help inform the public about the reasoning behind forest management decisions, and also to help obtain public input that could be used to improve management decisions.

LITERATURE CITED

Balas, E. 1963. Mathematical Programming in Forest Management. In *Proceedings of the Third Scientific Session on Statistics*, Bucharest, Romania, December 5-7, 1963.

Bare, B. B., B. H. Faaland, and I. Gupta. 1984. Timber Harvest Scheduling in the Presence of Spatial Constraints. Paper presented at the Joint National Meeting of the Institute of Management Sciences and the Operations Research Society of America. May 14-16, 1984, San Francisco, CA.

Burkhart, H. E., W. A. Leuschner, R. D. Stuck, J. R. Porter, and M. R. Reynolds. 1976. *Aids for Unit Planning on the Appalachian National Forests*. Division of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, VA. Publication no. FWS-1-76, 20 p.

Covington, W. W., D. B. Wood, D. L. Young, D. P. Dykstra, and L. D. Garrett. 1988. TEAMS: A Decision Support System for Multiresource Management. *Journal of Forestry* 86(8):25-33.

Dykstra, Dennis P., and James L. Riggs. 1977. An Application of Facilities Location Theory to the Design of Forest Harvesting Areas. *AIIE Transactions* 9:271-277.

Dykstra, Dennis P. 1981. Spatial Integrity in Forest Planning Models. In *Proceedings of the Symposium on Forestry: Issues for the Eighties*. Held at the International Institute for Applied Systems Analysis, Laxenburg, Austria, January 8-11, 1980. IIASA Collaborative Paper CP-81-3, p. 208-225.

Faustmann, Martin. 1849. Berechnung des Wertes welchen Waldboden sowie noch nicht haubare Holzbestände für die Waldwirtschaft besitzen. *Allgemeine Forst- und Jagd-Zeitung* 25:441-445.

Fox, B. E., M. A. Keller, A. J. Schlosberg, and J. E. Vlahovich. 1989. Opportunity Costs of Implementing Forest Plans. *Environmental Management* 13(1):75-84.

Gross, Thomas E. 1989. Use of Graph Theory to Analyze Constraints on the Juxtaposition of Timber Stands. M.S. thesis, Northern Arizona University, Flagstaff. 153 p.

Gross, Thomas E., and Dennis P. Dykstra. 1989. Harvest Scheduling with Nonadjacency Constraints. In *Proceedings, Society of American Foresters National Convention*. October 16-19, 1988, Rochester, NY. Society of American Foresters, Bethesda, MD. p. 310-315.

Hokans, R. H. 1983. Evaluating Spatial Feasibility of Harvest Schedules with Simulated Stand Selection Decisions. *Journal of Forestry* 81:601-603, 613.

Johnson, K. L., and H. L. Scheurman. 1977. Techniques for Prescribing Optimal Timber Harvest and Investment under Different Objectives -- Discussion and Synthesis. *Forest Science Monograph* 18. 31 p.

Jones, J. G., F. C. Hyde, III, and M. Meecham. 1986. *Four Analytical Approaches for Integrating Land Management and Transportation Planning on Forest Lands*. Intermountain Forest and Range Experiment Station, Ogden, UT. USDA Forest Service Research Report INT-86.

Kidd, W. E., E. F. Thompson, and P. H. Hoepner. 1966. Forest Regulation by Linear Programming -- A Case Study. *Journal of Forestry* 64:611-613.

Kirby, Malcolm W., William A. Hager, and Peter Wong. 1986. Simultaneous Planning of Wildland Management and Transportation Alternatives. In *Systems Analysis in Forestry and Forest Industries*, M. Kallio, Å. E. Andersson, R. Seppälä, and A. Morgan, Editors. Vol. 21, North-Holland/TIMS Studies in Management Science. Elsevier Scientific Publishing Co., New York. p. 371-387.

Leak, W. B. 1964. *Estimating Maximum Allowable Timber Yields by Linear Programming*. Northeastern Forest Experiment Station, USDA Forest Service, Upper Darby, PA. Research Paper NE-17, 9 p.

Loucks, D. P. 1964. The Development of an Optimal Program for Sustained Yield Management. *Journal of Forestry* 62:485-490.

Mealey, S. P., J. F. Liscomb, and K. N. Johnson. 1982. Solving the Habitat Dispersion Problem in Forest Planning. In *Transactions of the 47th North American Wildlife and Natural Resources Conference*, K. Sabol, Editor. March 26-31, 1982, Portland, OR. Wildlife Management Institute, Washington, DC. p. 142-153.

Meneghin, B. J., M. W. Kirby, and J. G. Jones. 1988. An Algorithm for Writing Adjacency Constraints Efficiently in Linear Programming Models. In *The 1988 Symposium on Systems Analysis in Forest Resources*, B. M. Kent and L. S. Davis, Technical Coordinators. USDA Forest Service General Technical Report RM-161, p. 46-53.

Nautiyal, J. C., and P. H. Pearse. 1967. Optimizing the Conversion to Sustained Yield -- A Programming Solution. *Forest Science* 13:131-139.

Nautiyal, J. C., H. S. Ngo, and H. K. Thadaney. 1975. Land Use Model for Planning: A Practical Application of Mixed Integer Programming. *Canadian Journal of Operations Research and Information Processing* 13(1):19-35.

Navon, D. I. 1971. *Timber RAM: A Long-Range Planning Method for Commercial Timber Lands under Multiple-Use Management*. Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Berkeley, CA. Research Paper PSW-70, 22 p.

O'Hara, Anthony J., Bruce H. Faaland, and B. Bruce Bare. 1989. Spatially Constrained Timber Harvest Scheduling. *Canadian Journal of Forest Research* 19:715-724.

Stuart, T. W., and K. N. Johnson. 1985. FORPLAN Version II: A Tool for Forest Management Planning. Paper presented at the Joint National Meeting of the Institute of Management Sciences and the Operations Research Society of America. April 29-May 1, 1985, Boston, MA.

Thompson, E. F., B. G. Halterman, T. S. Lyons, and R. L. Miller. 1973. Integrating Timber and Wildlife Management Planning. *Forestry Chronicle* 49:247-250.

Ware, G. O., and J. L. Clutter. 1971. A Mathematical Programming System for Management of Industrial Forests. *Forest Science* 17:428-445.

Weintraub, Andres, and Daniel Navon. 1976. A Forest Management Planning Model Integrating Silvicultural and Transportation Activities. *Management Science* 22:1299-1309.

Wood, D. B., B. E. Fox, and W. W. Covington. 1989. Computer-Based Approach for Teaching Multiresource Management. *Journal of Forestry* 87(11):11-16.

Date prepared: December 27, 1989

Credit: This paper was prepared for presentation at the XIX IUFRO World Congress, Montréal, Canada, August 1990.

ESTIMATING TIMBER VALUE GROWTH RATES IN NEW ENGLAND

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FDC : 653: (74)

Rates of growth in the value of standing timber can vary greatly from stand to stand and from tree to tree. In New England, compound rates of growth in stand value between the two most recent forest inventories ranged from -26 to 43%. Faced with this kind of variation, forest managers can use help in determining rates of value change for their woodlands. Analysis of forest inventory data identified four tree and stand characteristics--tree species, size, merchantability class and stand density--that can help us sort out the variation in value change. For example, 8-inch diameter white pine growing stock trees in stands with less than 80 square feet of basal area per acre have been growing in value at a compound average annual rate of 20.5 percent. That is ten times faster than 15-inch-plus soft maple growing stock in stands with more than 120 square feet of basal area. Results have been used to develop guides for estimating value growth potential for trees and stands in the region.

A SPREADSHEET MODEL FOR PLANNING THE SUSTAINABLE MANAGEMENT OF MALAYSIAN FORESTS

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FDC: 611: 624: (213)--01

The paper describes a spreadsheet model to plan the management of Malaysian forests. The model reads tree stocking data from a national forest inventory, and growth and mortality data from published reports. It determines the cutting limits for the initial harvest of the stand, simulates the harvest and projects the development of the residual forests for the next 90 years. Cutting limits, under the Malaysian Selective Management System (SMS), are determined so that (a) sufficient volumes are harvested to attract logging entrepreneurs, (b) adequate trees are left in the stands to form the next crop, and (c) the percentage of Dipterocarp species in the residual stand is at least the same as that in the original stand. Dipterocarps are the major commercial species in these forests. The residual stand is projected based on published growth and mortality data. Periodic harvests are simulated as and when the stands are ready for reharvest. Timber volumes, together with tree stocking and basal area, are estimated every 10-year projection period. Results indicate that the four major forest classes--Superior, Good, Moderate and Poor forests--can be managed on a sustained basis to produce timber at cutting cycles ranging from 30 to 50 years. The model provides a useful framework for the analysis of the sustainability of forest management in the tropics, in this case Malaysia. The estimates of future yields should improve the forecast of future timber production from the forests, especially if incorporated in a timber management planning model employing mathematical programming or other techniques.

A MICRO- AND MACROECONOMIC ANALYSIS OF DANISH DUNE FORESTRY

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The Danish state owns a comparatively large area of forests planted on former sand dunes. Since the wood production of these forests is low, the government has considered reducing management to a very low level or even selling the forests. This decision is based on thorough economic analyses. The microeconomic analyses are traditionally from a theoretical point of view, but the outcome is interesting. The macroeconomic analyses apply a new theoretical concept developed for general government use. With their application to forestry, theoretical problems have arisen, and the outcome has caused much debate.

RADR = risk-adjusted discount rate (RADR = r + risk component). Used to discount expected cash flows, E(CF), as an alternative approach to calculating NPV_{CE}.
W_o = individual's wealth endowment, assumed constant through time.
U(W) = individual's utility of wealth function. $W = W_o + CF$, or $W = W_o + NPV^{(un)}$ depending on whether future wealth or present wealth is being addressed.
E[U(W)] = Expected utility from the uncertain investment opportunity (a measure of individual satisfaction).

If all future positive and negative cash flows from investments were certain, one could discount these with a risk-free rate to calculate net present value. Although disagreement abounds on the proper real risk-free interest rate, historical averages suggest a rate between 1 and 4 percent (Ibbotson and Sinquefield 1977 and Carlson 1977).

In reality, most cash flows (CF) at any time are uncertain and could be represented by a probability distribution (henceforth "distribution") of outcomes such as in Figure 1. While this distribution could be expressed as an expected value, $E(CF^{(1)}) = 0.25(300) + 0.50(500) + 0.25(700) = \$500$, such a value does not reflect the cash flow risk (i.e., variance). For example, the cash flow distribution in Figure 2 has the same expected value as that in Figure 1: $(E(CF^{(2)}) = 0.15(100) + 0.20(300) + 0.30(500) + 0.20(700) + 0.15(900) = \$500)$, but the risk is greater due to a higher cash flow variance. Thus, simply discounting expected values with a risk-free rate (as suggested by Foster 1979) essentially ignores risk (Chang 1980).

One approach is to discount cash flow distributions for a given project using a risk-free discount rate to arrive at a net present value distribution for $NPV^{(un)}$. Decision makers could then subjectively rank these net present value distributions in terms of desirability and choose the preferred alternative accordingly (Chambers et al. 1986). However, this approach does not permit assigning a single number (e.g., an NPV) to each project for ranking purposes[1]. One solution is to express each cash flow distribution at time t as a "certainty equivalent" (CE) -- an amount which, if received with certainty, would bring the investor the same welfare as the uncertain cash flow. For the risk averse individual (the case assumed here), $CE < E(CF)$ for revenues[2]. Risk-averse individuals are willing to accept a certain cash flow which is less than the expected cash flow, to avoid risk. Since CEs are conceptually risk-free, they can be discounted with the risk-free rate (r) to arrive at NPV_{CE} for the project (Brigham 1985). Therefore, NPV_{CE}, which we will consider the correct present value, is a single value measure of the individual's welfare from an uncertain investment.

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[1] Here we abstract from the question of project scale. Given capital rationing, one should compare projects with similar capital requirements.

Since $E(CF) > CE$ (for revenues), there exists some risk-adjusted rate $(RADR) > r$ which will discount the E(CF)s in aggregate to exactly equal NPV_{CE}. That is the aim of using risk-adjusted discount rates. The problem is that, due to different risk and timing among cash flows, each E(CF) is likely to require a different RADR, or if an average single RADR is selected to arrive at the correct NPV_{CE} for one project's cash flows, the RADR would generally differ for each project (Cathcart 1989). Furthermore, an unbiased estimate of NPV_{CE} under the RADR method would first require determining CEs, in which case the net present value problem could already be neatly solved by discounting the CEs with r (Robichek and Myers 1966).

This paper's objective is to show, for selected investments, how much the risk free rate must be increased when discounting expected values to arrive at correct estimates of NPV_{CE}. Policy implications and future research needs are discussed.

Approach

Individual satisfaction from uncertain cash flows was measured by expected utility. Expected utility is the mean utility calculated across all cash flow outcomes. For example, if U(W) describes the individual's wealth utility for cash flow outcomes (figure 3), then the expected utility from the uncertain cash flow $CF^{(1)}$ would be: $E[U(W_o + CF^{(1)})] = (0.25)U(W_o + 300) + (0.50)U(W_o + 500) + (0.25)U(W_o + 700)$. Accordingly, $E[U(W_o + CF^{(2)})] = (0.15)U(W_o + 100) + (0.20)U(W_o + 300) + (0.30)U(W_o + 500) + (0.20)(W_o + 700) + (0.15)U(W_o + 900)$. While the E(CF)s are the same for $CF^{(1)}$ and $CF^{(2)}$, $E[U(W_o + CF^{(1)})] > E[U(W_o + CF^{(2)})]$ under risk aversion, which is illustrated by Figure 3, where U(W) is concave from below. In that case, the individual's utility from $CF^{(1)}$ exceeds that from the riskier $CF^{(2)}$ because less utility per added dollar would result from the higher values in distribution 2.

Rather than apply the expected utility model at each time t to arrive at the certainty equivalent cash flows, we estimated the probability distribution for net present value outcomes and only applied the expected utility model to this distribution at t=0. This not only reduces the number of calculations in the analysis, but avoids the need to know the individual's utility function and wealth position in all future time periods.

Given the individual's wealth endowment, NPV_{CE} for an investment was determined using the following relationship

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[2] We will only consider uncertain benefits. Cathcart (1989) reviews the case for uncertain costs.

$$(1) \qquad U(W_o + NPV_{CE}) = E[U(W_o + NPV^{(un)})]$$

Relation (1) states that the sum of utility from W_o and the utility from the certainty equivalent net present value must equal the expected utility from both W_o and the net present value distribution for the entire investment (i.e., all cash flows for that alternative). This expected utility on the right side of (1) was expressed as a function of the mean, variance, and skewness of the net present value probability distribution, using the Anderson *et al.* (1977) moment approximation method (see Cathcart, 1989). Utility on the left side of (1) was expressed as a negative exponential or a logarithmic function of W_o and NPV_{CE} under different degrees of risk aversion. Such functions, concave from below, fell within the range of empirical estimates (see Wilson and Eidman 1983, and Litzenberger and Ronn 1986). In the resulting equation, since all values except NPV_{CE} were known, we could solve for the latter. The correct RADR for each investment would be that which satisfied the following equality:

$$NPV_{CE} = \sum_{t=0}^{n} \frac{E(CF)_t}{(1 + RADR)_t}$$

Rather than determine the correct RADR explicitly for each investment, we estimated a net present value schedule for various RADRs containing risk components of 0.5, 1,...3.5, and 4 percent (figure 4). As figure 4 indicates, the correct RADR can be identified from this schedule.

Four investment alternatives were simulated for 30 acres of cut-over land in the central mountains of Virginia: loblolly pine sawtimber, loblolly pine pulpwood, custodial management of mixed hardwood-pine, and forage hay production. Costs were considered certain and remained fixed at typical levels in constant dollars. Models were developed to simulate typical fluctuations in biological yields, product prices, and rates of regeneration failure. To correct for unequal lives, each cash flow sequence was repeated until additional repetitions made minimal contributions to net present value (generally from 100 to 150 years). Through repeated simulation, net present value probability distributions (the $NPV^{(un)}$ in equation (1)) were estimated for each alternative, given a constant real risk-free discount rate of either 2, 3, or 4 percent. Details of the analysis are in Cathcart (1989).

Results

When discounting expected values of cash flows with an RADR to estimate NPV_{CE} for each alternative, our analyses indicated that very small additions to the risk-free rate were required: 1/2 percentage point or less, given real risk-free rates of 2, 3 and 4 percent. For the investment alternatives considered, Figure 4 shows a typical comparison between NPV_{CE} and the present values computed by discounting mean cash flows $E(CF)_t$ with different RADRs. As we added more than the appropriate risk component to the risk-free discount rate, the ranking of projects differed from the correct ranking. Furthermore, too much adjustment for risk will bias rankings against the selection of long term timber investment (Cathcart and Klemperer 1988).

The ranking of alternatives was affected more by the choice of risk-free discount rate rather than by errors in specifying risk components. Increasing the risk-free discount rate had the effect of increasing the individual's sensitivity to risk since higher rates markedly lowered the mean net present value. As r increased from 2 to 4 percent, the preferred alternative for risk averse individuals switched from the sawtimber investment to the essentially risk-less custodial management alternative. Changing the specification of the individual's utility function (i.e., from negative exponential to logarithmic), or changing the degree of risk aversion did not change these results.

Discussion and Conclusions

Our results indicate smaller risk adjustments to risk-free discount rates than are commonly suggested. For example, Sedjo (1983) proposed adding a 10 percent risk component to a 5 percent real risk free rate. The U.S. Office of Management and Budget's suggested 10 percent real before-tax discount rate implies at least a 6 percentage point risk component, considering 4 percent as a maximum risk-free rate.

We qualify our results as follows. Our estimated risk component of 0.5 percent (or less) ignores catastrophic losses from weather, fire, and pests. Perhaps more significantly, our price simulations were only based on random cyclical deviations from historical trends, and did not consider uncertainty in the location (or shifts) in the trends themselves. While the simulated results exhibited a wide range of net present value outcomes for each alternative, these catastrophic and policy oriented events could lead to larger estimated risk components. However, for the long time horizons considered here, we feel that even if these events were accounted for, the estimated RADRs would still fall markedly below those with large risk components in the neighborhood of 6-10 percent.[3] Finally, we noticed a risk-dampening effect of considering investments over many rotations. For example, poor performance in one rotation could be offset by better performance in the next. For risky, non-repeating, short-term investments of 5 years or less, appropriate RADRs could often substantially exceed those found in our analysis, given the same cash flow variance.

We should also stress that the correct application of the RADR approach involves discounting mean cash flows with the RADR, not optimistic cash flows. It is not at all clear that most investors project their cash flows as true expected values (E(CF)). While many future costs might seem more certain (less volatile) than product prices, there may be a tendency to under-estimate expected values of costs for cases such as regeneration or brush control. Analysts will often assume an average value for such costs without considering that they are sometimes incurred two or more times on the same area. In addition, yield projections and econometric price forecasts may often be optimistic. The result is that investors' projected net incomes may often exceed the true mean or expected cash flows assumed here.

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[3] Sedjo's (1983) 10 percent premium may be adequate to account for what he called political risk, especially in developing countries. However, this type of risk would be endemic to all investment opportunities and should not be construed as an adjustment for the riskiness inherent in forestry cash flows, the case being addressed here.

Discounting such optimistic cash flows as opposed to the true mean values would suggest adding a greater amount to the risk-free rate than found in our analysis. However, the magnitude of this adjustment would be completely arbitrary and would probably lead to investment rankings which failed to maximize investor utility.

Future research should concentrate on estimating probability distributions for different forestry cash flows. If we discount true mean cash flow values, the appropriate risk components in the discount rate may well be considerably less than typically suggested. The disparity between suggested risk components and our estimated results signals a need to develop and apply risk analysis techniques other than the RADR approach. Adding too large a risk component to the discount rate could bias investment decisions against long-term ventures and reduce total returns to society's capital stock.

Literature Cited

Anderson, J. R., J. L. Dillon, and J. B. Hardaker. 1977. Agricultural decision analysis. Iowa State University, Ames, Iowa. 344 pp.

Brigham, E. F. 1985. Financial management theory and practice. Fourth Edition. The Dryden Press, Chicago, Illinois. 1128 p.

Carlson, J. A. 1977. Short-term interest rates as predictors of inflation: Comment. American Economic Review 67(3):469-475.

Cathcart, J. F. 1989. Evaluating risk-adjusted discount rates in forest investment decision making. Ph.D. dissertation. Virginia Polytechnic Institute and State University. Blacksburg. 280 pp.

Cathcart, J. F. and W. D. Klemperer. 1988. Estimating uncertain timber returns for landowners. Do risk adjusted discount rates lead to the right decision? P. 44-69 in Proceedings of the 1988 southern forest economics workshop, forest resource economics: Past, present and future. Abt., R. C. (editor). School of Forest Resources and Conservation, University of Florida, Gainesville. pp. 44-69.

Chambers, P. C., S. A. Sinclair, C. Hassler, and B. G. Hansen. 1986. Forest products investment model: a micro-computer tool for incorporating risk into capital budgeting. Forest Products Journal 36(1):64-68.

Chang, S. J. 1980. Discounting under risk: Comments on adjusting discount rates. Journal of Forestry 78(10):634-635.

Foster, B. B. 1979. Adjusting discount rates for risk. Journal of Forestry 77(5):287-288.

Ibbotson R. G. and R. A. Sinquefield. 1977. Stocks, bonds, bills, and inflation: The past (1926-1976) and the future (1977-2000). The Financial Analysts Research Foundation, Charlottesville, Virginia. 106 p.

Litzenberger, R. H. and E. I. Ronn. 1986. A utility based model of common price movements. The Journal of Finance 4(1):67-92.

Robichek, A. A. and S. C. Myers. 1966. Conceptual problems in the use of risk-adjusted discount rates. Journal of Finance 21:727-730.

Sedjo, R. A. 1983. The comparative economics of plantation forestry: a global assessment. Research Paper 0-8010-3107-5. Resources for the Future, Washington DC.

Wilson, P. N. and V. R. Eidman. 1983. An empirical test of the interval approach for estimating risk preferences. Western Journal of Agricultural Economics 8:170-182.

ECONOMIC PROBLEMS OF FORESTRY IN HUNGARY AFTER THE ECONOMIC REFORM IN 1968

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FDC: 903: (439.1)

The economic reform introduced in 1968 increased the independence of forest management organizations, and annual profit came into prominence. Although independent State Forest Inspectorates were established for controlling the forest enterprises' activities related to the prescriptions of management plans, forest resources deteriorated because of the annual enterprise interests and the financial difficulties of the national economy.

Therefore, the modernization of forestry management is aimed at the enforcement of sustainable, progressive yield management more than short-term financial benefits. For this purpose, investigation of change in the value of forest resources may be an important issue and a factor influencing the annual profit. According to our method, this change is related to income which may be obtained by management, exercised in compliance with the prescriptions of the management plans. If the actual annual profit exceeds this income year by year, reduction in the producing ability of the forests and thus, in the value of forest resources is verifiable. Otherwise, an increase in the value of forest resources occurs and the value-excess resulted in this way may be utilized under unfavorable market conditions without any restrictions.

The earlier development of forestry was for wood harvesting and hunting. In the future, we must change to a well-organized multipurpose forestry. Establishment of legal and economic conditions for attaining this goal has come into prominence. Within the frame of these measures, Forest Inspectorates cooperating with local governments and organizations representing various social interests are of great importance.

ESTIMATING DISCOUNT RATE ADJUSTMENTS FOR FOREST INVESTMENT RISK

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FDC: 651.1

SUMMARY

One of the most common ways to account for investment risk is to add a risk factor to the risk-free discount rate when computing present values of expected cash flows which are uncertain. Using certainty equivalent analysis, we show that the correct risk factor for repeating investments with long time horizons is likely to be far smaller than commonly believed--on the order of 1/2 percentage point or less for selected cases. Policy implications and limitations of the analysis are discussed.

INTRODUCTION

The theory of proper accounting for risk in investment analysis is well developed. However, due to inadequate data, the practice of risk analysis in forestry is usually fairly primitive. The most common approach is to discount future cash flows with a risk-adjusted discount rate. This paper discusses some of the problems in estimating risk-adjusted discount rates and in determining the types of values to which these rates should be applied.

The following notation is used:

CF - an uncertain cash flow at a given time, represented as a probability distribution (for example, see Figure 1 or 2).
E(CF) - expected value (or mean value) of an uncertain cash flow.
CE - certainty equivalent for an uncertain cash flow.
t indexes years from 0 to n, the investment duration.
r - real risk-free discount rate (excluding inflation). Assumed constant over time.
$NPV^{(un)}$ - uncertain net present value for the investment alternative, represented as a probability distribution of net present value outcomes where each outcome is calculated using the risk-free discount rate.

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*This research was funded in part by a grant from the United States Forest Service Southeastern Forest Experiment Station.

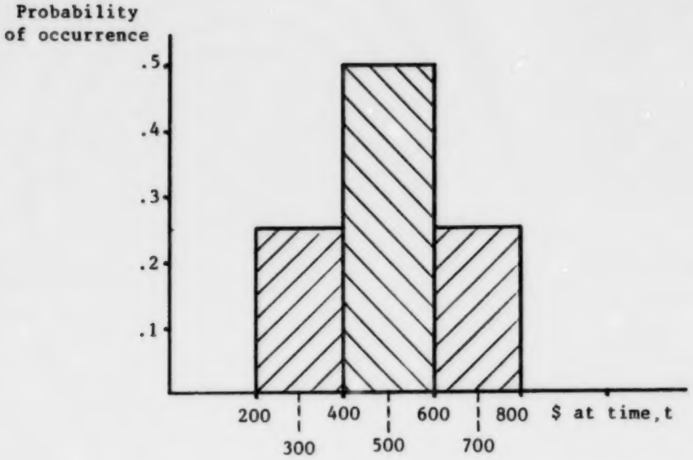

Figure 1: Cash flow 1 ($CF^{(1)}$).

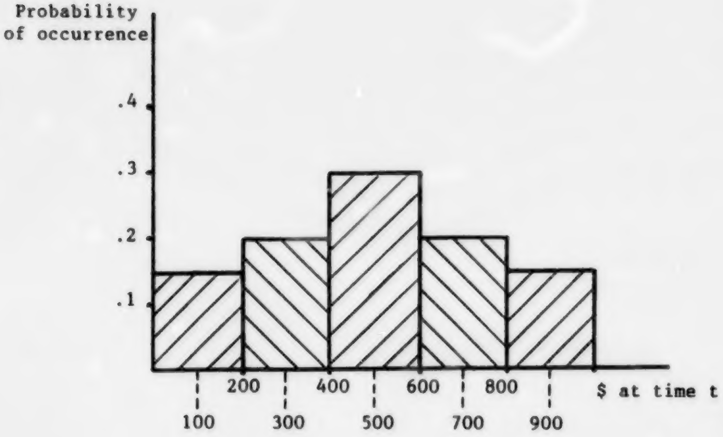

Figure 2: Cash flow 2 ($CF^{(2)}$).

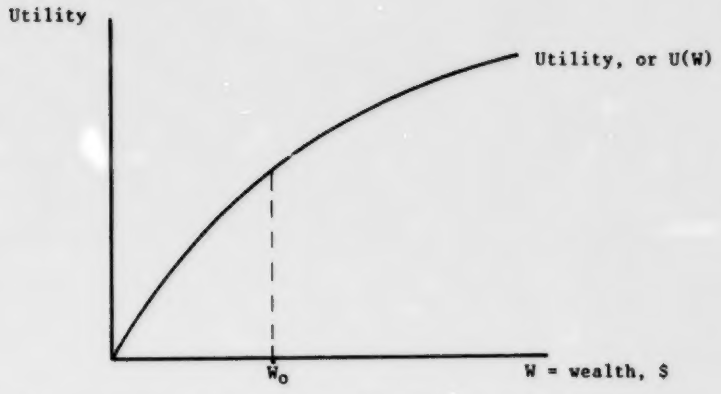

Figure 3: Risk-averse individual's utility function for wealth.

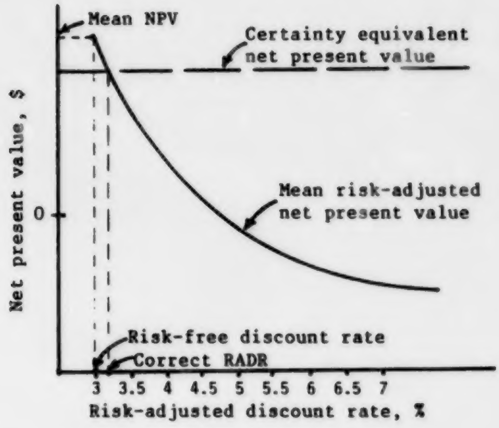

Figure 4: Illustration of RADR valuation bias for alternatives in the empirical analysis. This pattern was representative of the simulated alternatives. A 3-percent risk-free discount rate was used. The pattern also reflects the results when the risk-free rate was 2 or 4 percent. However, the range of risk-adjusted discount rates over which the mean risk-adjusted NPV remains positive will vary (i.e., lower under higher risk-free discount rates).

MANAGEMENT OF PEDUNCULATE OAK FORESTS

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FDC: 62: 176.1 Quercus L.

Management of pedunculate oak forests is quite old in our country. The first management plan dates from 1875. All the forests have been divided into compartments by means of a large system of roads. These compartments are still the smallest permanent management units. There are about 264,000 hectares of pedunculate oak forests in Yugoslavia (64% in Croatia, 25% in Vojvodina, 11% in Bosnia and less than 1% in Slovenia).

In Croatia, there are 64 management units with 165,000 hectares of pedunculate oak forests which are mostly used for the production of high quality oakwood. Apart from these forests, there are about 3,300 hectares of pedunculate oak forests in Croatia which have a special purpose (hunting, protection, etc.). Growing stock of the pedunculate oak forests of Croatia amounts to 35 million cu.m. The age 120 years has been chosen as the exploitable age in which the pedunculate oak reaches 53 ± 14.01 cm as the mean diameter at breast height outside bark.

CAN NATIONAL FOREST PLANNING BE CONSISTENT WITH LEOPOLD'S LAND ETHIC?

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FDC: 903: 651: 907: (73)

Planning for the U.S. National Forests under the National Forest Management Act has so far been carried out using a benefit/cost analysis approach. This is implemented using a linear programming model (FORPLAN) which attempts to maximize discounted net public benefit. Any approach such as this involves trading off some benefits against others to achieve the "optimal compromise." This is essentially a rational utilitarian approach to planning which assumes that the most important factors can be quantified and compared using cardinal measures. Concurrently, there are movements in the forestry profession towards embracing a Leopoldian Land Ethic (Journal of Forestry, June 1989). This ethic states that management actions should be designed to enhance the "stability, integrity and beauty of the biotic community." At least the last two of these three factors do not lend themselves to cardinal measure and have absolutist, as opposed to relativistic, interpretations. Thus the question arises: "Can National Forest Planning be made consistent with Leopold's Land Ethic?" The importance of the question is reflected in the deep-rooted and fundamental disagreements that detractors from the current planning methodology are voicing; they seem to feel betrayed by the very nature of the chosen planning tools. Yet, the idea of a Land Ethic is not new and adherents are found throughout the forestry profession. This paper will attempt to answer the compatibility question and discuss the implications for forest planning.

FOREST MANAGEMENT PROBLEMS IN THE CASE OF FOREST SUSTAINED MULTIPLE USE

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FDC: 916: 903: (47)

SUMMARY

The sustained multiple use of forests demands improving the economic mechanism of managing the long-term process of extended reproduction of forest resources. The paper considers problems of managing forests as the property of the whole nation, suggests recommendations to improve forest estimation, forestry organization and planning and supervision of the forest resources users' activity for the USSR forestry in the period of perestroika.

Keywords: Sustained multiple use, forest management, long-term programmes of forest resource reproduction.

The requirements of sustained and multiple forest use have been known for a long time, since the origin of forest management. Many nations have fixed them in their legislative acts. The USSR legal document called "Basic Principles of Forest Legislation of the USSR and Union Republics" recognizes them to be the main guidelines for forestry and forest industries. They undoubtedly meet ethical and ecological requirements of natural resources use, which should be the only basis of economic programmes for the development of forestry and forest industries.

But unfortunately, these requirements are, for the most part, only declared. The interconnection of these requirements has neither been properly comprehended, nor implemented within the economic structure of production, its planning and technological opportunities, and it has practically no legislative protection in the system of forest management.

The concept of forest sustained yield, previously called "non-declining even flow", has been applied mainly to forest cutting regulation, i.e. methods, schedules and harvested volumes of timber as a forest resource. As for non-timber forest resources (food, forage, medicinal and technical ones), as well as various protective and social utilities of forests, it has been assumed that they reproduce themselves on their own in the course of growing-forest use and do not require any specific measures and inputs for their realization. However, the practice of directing forest exploitation to only one resource has shown that it leads to forest improverishment and cannot provide the conditions for reproduction of non-timber forest resources.

We could give a lot of examples to confirm the statement above. In the USSR, a grave harmful effect was brought about by industrial loggings in taiga forests where concentrated clear-cutting had been based on machinery, which destroyed vigorous young growth of valuable species and ground cover with rich berry crops, compacted the soil, greatly disturbed the hydrologic regime, thus causing general succession of tree species, landscape changes, destruction and damages of minor rivers, sharp changes of fauna and general deterioration of the environment.

The separation of hunting from forestry has also been very harmful for forests and their management. It is well-known that the moose makes the establishment of coniferous plantations very difficult in many regions and republics. In the Southern regions, herds of boars impede oak reforestation.

Around big cities, recreational forests are allocated in the green zones. At the same time, they are very important for water- and soil-conservation. We should also take into account timber harvesting in the process of renewing and forming the forests so that they satisfy a set of requirements according to their site conditions.

It is obvious from the examples above that even if direction of forestry to a single resource may be acceptable for some types of special-purpose management (rapidly-growing tree plantations, willow plantations, etc.), it does not meet the requirements of sustained multiple use, applied to the bulk of forest areas in the USSR.

The problem of forestry, directed not to a single goal, but to a set of goals according to the structure of demands in each region, is no longer an abstract one, it has become a vitally important and most urgent trend of research and practice. It is only integration and coordination of the goals with the ways to reach them, based on the system approach that can help solve this problem adequately. We have already described the system approach to the development of for forest multiple-use strategies for large areas (1). To avoid repetitions, we consider here the problems of forest management associated with this approach implementation.

Perestroika has made scientists and experts of the USSR develop the concept of forest management as a holistic system of economic, organizational, nature-conservating and legislative measures. The suggested system implies payments for forest resources, regarded as the most important source of their reproduction funding and an economic guarantee of forest sustained multiple-use.

So far, payments have been taken for timber in the form of forest taxes. Their present-day level (2rbl/m , on the average for the country) does not compensate the inputs to reproduce the resource. They are planned to be increased 3-4 times with due regard to the inputs to reproduce the timber removed and differential rent. Taxes for other forest resources are to be established when the latter ones become the objects of industrial harvesting and leasing.

Forestry planning should rely on scientifically based normatives of sustained yield from those forest resourcs which are considered to be targets at an enterprize. Forest management plays a leading part in defining such normatives, the significance of forest management for managing forest resources continues to grow. Now new forest management guidelines are under way. They state that the purpose of forest management is to develop economically-based long-term programmes of forest resources reproduction by alternatives, according to the levels of forestry intensification. Besides forest management experts, local forest officers may participate in the development of such programmes to introduce more of practical and scientific achievements, proved to be useful. In the framework of forest management improvement, the methods of sustained yield calculation are being updated. Scientists of different institutes have submitted their proposals on defining the criterium for the choice of allowable cut for various age distributions of forest stands. The statement is being proved that to adjust the levels of forest use to the scale and rates of forest maturing, it is necessary to estimate the cut on the basis of long-term programmes of forest resources reproduction (2). To solve this problem appropriate simulation models are suggested. As for the nearest future, forest science faces the task to develop an evaluation method for sustained multiple forest use (of a set of resources). This work is also planned to be done using the long-term programmes of forest resources reproduction, based on integrated regional systems of measures (IRSM). The later ones are coordinated (interrelated, instead of autonomous) resource-wise systems of measures.

In connection with organization and control of forest multiple use, forest mensuration researchers are facing the task to ensure simulteneous and coordinated estimation of all forest resources by respective territorial units of the forest lands. To provide directed management of the long-term process of forest growing within the whole country, a proper system of forest resources estimation is to be established with the help of aerial and satellite monitoring with step-wise computerization for a continuously updated data bank, providing unbiased characteristics of forest resources by regions.

The system of forestry funding is also intended to be restructured in connection with introducing the cost-accounting for forest growing. The cost-accounting is based payments not for separate operations but for the outputs (established forest plantations, drained or economically used forest areas, etc.) in accordance with definite prices. The models developed are now experimentally tested. They have been covered in publications.

The above-listed measures may bring about a positive effect if an adequate form of forest management corresponds them at different hierarchic levels. So far, it remains a problem of discussion. At the same time, some positions are singled out in this decisive direction which require more attention than it used to be paid to them.

In the USSR, forests belong to the whole nation. However, the management of forests, as the property of the whole nation, and their use were under forest-using ministries, who actually pursued the policies of their own interests without due regard for national economy proper functions of the forest in a broad sense, and it has led to grave harm for the forests and environment (depletion of forests in numerous regions rich in forest, tree species succession, impoverishment of species composition, disturbance of the hydrologic regime, etc.). Long ago, a number of Soviet scientists turned their attention to the fact that as forest growing and multiple functions cover very long periods of time, the regulation of economic relations demands that two forms of management should be distinguished, and it would not be reasonable to mix them and entrust to one and the same body or enterprize. The first form refers to the management of forests and expresses the interests of the whole nation's property for forests. Its functions include development and implementation of a long-term continuity policy, directed to dynamic balancing of forest resources demand and supply, preventing forest depletion and environment decline. The other form may be referred to managing the production activities on the part of a definite user of a forest resource or forest lands, leased for a certain term. The forest user's functions may include not only harvesting but also reproducing forest resources. In this case, it may be still reasonable to have complex forest enterprizes which could lease forest lands or resources.

The first form of managing the forests is the leading, directing and coordinating one, in relation to the second form (managing the production activity of the user of a forest resource) which is subordinate to the first one. The management of forests should be controlled by a non-ministerial body and services, subordinated to it vertically, playing the part of forest lands holders with legally granted rights of an authorized representative of the whole nation's property.

The USSR 1st Congress of People's Deputies marked the starting point of separating the legislative and executive authorities in governing the country, which is an inalienable feature of a lawful state. Similar separation should be made between the functions of various ministries and the organization of forest users, representing executive authorities.

In the USSR, forest users are various ministries, among them, the USSR Ministry of Forest Industries is the most significant user of timber raw material. The total number of user-ministries is measured by tens and it will be growing in connection with extention of the cooperative movment. The transfer of all these organizations to full cost-accounting and leasing relations will enhance the implications of forest managing functions of the forest lands holder as a coordinating body for pursuing the whole nation's interests ofr forest use.

The part of the forest lands holder could and should be played by the USSR State Committee for Forest and its subordinated republican and regional branches and forestry enterprizes. But the point is that these bodies fulfill not only the functions of the forest lands holder but also those of the forest user. They are responsible for harvesting timber and other forest resources and their processing as well. Thus, they loose the right for the State supervision which they claim to have because they have turned out to be in the role of a user-ministry.

It is natural and rightful to raise the question of establishing the bodies for managing the forests along the entire hierarchic vertical in the form of a Forest Service which should be free from the forest user's functions.

What can and must be included in forest management functions of such an upper body? Here we shall touch upon the urgent measures associated with the four singled out functions; estimation, planning, organization and supervision. First of all, it is the arrangelment of timely, regular and unbiased estimation of forests and forest resources, using modern technical aids, including aerial - satellite and ground equipment, providing data for an annually renewed data-bank on forest resources. On the basis of this estimation, the Forest Service should develop scientifically-founded normatives of forest resources sustained yield, which are to become the foundation of contract lease relations with forest users. To develop long-term forest policies, the planning function of the Forest Service should include working out (together with the other ministries concerned) long-term nation-wide and regional programmes of forest resources extended reproduction, directed to dynamic balancing the demand and supply of forest products and services. The USSR Supreme Soviet suggested that a programme of the environment ecological sanitation. The methods for working out such programmes have been developed by Soviet scientists and may be used for the suggested goal. The author of this paper also took part in this development (2,3). On the basis of these very long-term programmes, the Union and Republican branches of the Forest Service may and should formulate the State order for the most important activities of the cardinal significance, ensuring a rise of forest yield or extention of forest areas on the lands that may be transferred into forest lands from other uses. To fulfill such important State orders, a centralized fund, relying on various sourcs of subsides, is needed. In this case, we should consider the positive foreign experience of long-term programme funding.

As for the organization function of managing the forsts, it has a strategic character, compared to the organization of current economic activities. It refers to classifying the forests according to their meaning for national economy; working out legislative acts and determining the methods and schedules for forest resources use, as well as rules and main issues of forest resources reproduction.

The Forest Service functions should also incorporate the State (not ministerial) supervision of observance of the forest use rules and those of reforestation and forest protection and conservation. To work out and implement the scientific and technical policy, the upper body has at its disposal a network of research and development organizations.

But it should have respective bodies at the lower level, as well. The opinions about their character differ. Earlier, it was proposed to create forest commissions of the inspection type on different levels of management. Without denying the possibility of selective revisions by inspectors, the author thinks that they alone will not be able to realize the function of managing the forests.

It is important to bear in mind, as Pr. M.M. Orlov noted in his time, that to make the long-term process of forest growing successful, we should not point out to the mistakes and abuses but avoid them instead, since it becomes practically impossible to correct them, having lost the time as well as the inputs. According to the essence of his role, the inspector cannot be responsible for the condition of forests. It is the officers and respective services, responsible for their forest lands as the national property, who may and should be charge of forests since they are granted juridical rights and economic opportunities by the legislative authorities.

The central person at the lower level of the Forest Service should be the ranger. It is forest ranges within a district (headed by the district forestry officer with his subordinate Forest Service staff) that are to fulfill the functions of managing the forests at the lower level. Their duties will include the inventory of all the alternations on the forest lands, participation (together with forest management experts) in working out the programmes of forest resources reproduction, schedules of cuttings and reforestation; allocating forest cut areas; preparing the orders (contracts) of complex forest enterprises and other forest users-organizations for carrying out reforestation measures, their funding and acceptance. The ranger prepares contracts for lease-holders of various types, and supervises their fulfillment. Forest ranges within one district may have double subordination: to the district Soviet of People's Deputies (along the line of the local Soviet authorities, relying on the legislative power within their competence) and to the Forest Service (along the line of the scientific and technial policy realization).

If the area is large, district ranges may be divided into sectional ranges, headed by sectional rangers.

At the regional level, forest ranges should be subordinate to the forest department of a regional Executive Committee (local authorities), headed by the Chief Forestry Officer.

This type of double subordination of the former forestry enterprises existed before as well, and it did not prevent them from fulfilling their functions.

At the level of a forest range, the Forest Service should fulfill the function of managing the forests entrusted to it (estimation, planning, organization and supervision) and not in isolation, not separately for each resource but system-wise, integrally for the whole set of resources, coordinating and interrelating the activities of forest users of all types on the basis of contracts, taking into account the national economy goals of forests.

The economic relations should be also regulated with regard for this system of managing the forests. The rangers should be interested in the full levy of forest taxes for the resources used, and should be able to dispose of the portion of this money, meant for reprodution to implement the forest sustained multiple use.

The Forest Service staff, being essentically the supervisors of natural forest treasures, should be fundamentally trained, have high juridical prestige and material independency of forest using organizations. As it was noted in the Declaration of the VIII World Forest Congress, they "should be placed high enough and have sufficient political support to fulfill their duties efficiently for the benefit of people.

The establishment of the Forest Service, having the functions of managing the forests, the enhancement of the role of local rangers, being the central officers, coordinating rational use and reproduction of the whole set of forest resources on the real cost-accounting basis, will allow to implement the forest sustained multiple use to satisfy the growing needs of people and protect and improve the environment.

LITERATURE CITED

Komkov, V.V and Moiseev, N.A. 1987: Optimizatsia vosproizvodstva lesnykh resursov (Optimization of forest resources reproduction). "Lesnaya promyshlennost; Moscow.

Moiseev, N.A. 1986: System approach to multiple forest use management strategy for large areas. XVIII IUFRO World Congress, D.4, Planning, economics, growth and yield, management policy, Ljubljana, pp. 183-191.

Moiseev, N.A. 1980: Vosproizvodstvo lesnkh resursov. (Forest resource reproduction). "Lesnaya promyshlennost", Moscow. 264p.

ERROR SOURCES AND PROPAGATION IN DECISION SUPPORT SYSTEMS FOR NATURAL RESOURCE MANAGEMENT

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The next generation of forest management tools promises to integrate spatial relationships from geographic information systems, projections of future conditions by simulation models, and management advice from expert systems and/or optimization algorithms into interactive, computer-based decision support systems. Geographic information systems provide the spatial linkages for attributes within these systems, but can introduce substantial errors into area-based analyses. While predictive uncertainty has been estimated in expert systems and in deterministic simulation models, integration of the resulting errors presents a challenge. Uncertainty in results from these procedures can cause sub-optimal allocation by linear programming-based resource models. A hypothetical decision support system is presented to illustrate error sources and possible error propagation techniques.

AN INTERACTIVE FUZZY SATISFICING METHOD FOR MULTIOBJECTIVE LINEAR PROGRAMMING PROBLEMS IN FOREST PLANNING SYSTEMS

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A new interactive fuzzy satisficing method is presented for solving multiobjective linear programming problems in forestry by assuming that the decision-maker (DM) has fuzzy goals for each of the objective functions. After determining the membership functions for each of the objective functions through the interaction with the DM, if the DM specifies his/her reference membership values, the minimax problem is solved by the combined use of the bisection method and the linear programming technique, and the DM is supplied with the corresponding Pareto-optimal solution and the trade-off rates between the membership functions. Then by considering the current values of the membership functions together with the trade-off rates, the DM responds by updating his/her reference membership values, and the compromise or satisficing solution for the DM can be derived efficiently from among a Pareto-optimal solution set. The use of this method encourages more flexible forest planning, a problem when human judgment and estimation are influential.

FOREST TENURE POLICY IN CANADA:
THE INTERFACE OF PRIVATE AND PUBLIC INTERESTS

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SUMMARY

Forest policy in Canada is based largely on public ownership of resources and private utilization of them. The critical relationships between public owners and private users are established through the distinctive forest tenure systems of provincial governments. Today, the forest industry depends mainly on long-term, renewable licenses that assign to their holders not only the right to harvest timber but also extensive responsibilities for developing, protecting and managing public forests. These licenses have significant advantages in the Canadian context, but they fail to provide their holders sufficient security to encourage voluntary silviculture, a problem of increasing concern to policy-makers as the industry shifts from the original endowment of natural timber to managed forests. This suggests a need for further development of tenure policy, in particular a need for innovations to provide those who are depended upon to undertake forest improvements with a stronger proprietary interest in the forest crops they manage.

INTRODUCTION

Few countries are so richly endowed with natural resources as Canada, and few industrial economies are so heavily dependent on natural resource industries. By many measures, the most important of Canada's natural resources is its forests. Covering some four million square kilometres, and containing nearly 23 billion cubic metres of timber, Canada's forest resources exceed those of the United States and are more than double those of Europe. Although Canadian wood production, of about 170 milliion cubic metres annually, falls well short of production in the United States, Europe and the Soviet Union, Canada is the leading exporter of manufactured forest products. Nearly half of the timber is produced in the westernmost province of British Columbia.

Canadian policy-makers have developed unique institutional arrangements for managing forests. This is a result of a deeply entrenched commitment to public ownership of forest land on the one hand and, on the other, an equally strong commitment to the private sector for harvesting and utilizing timber. To reconcile these choices, Canadian governments have devised a wide variety of usufructuary rights to provide private access to public (or Crown) resources. These rights, in the form of leases, licenses and permits, are the primary means of reconciling the interests of the private users with those of the public landlords. They also have a major influence on how resources are managed and developed, the division of responsibilities for these activities, the efficiency of the dependent industries and the distribution of the economic benefits from resources used. They are thus major instruments of resource policy.

This paper examines some aspects of the Canadian experience in attempting to harmonize public and private interests in the industrial use of forest resources. Special attention is drawn to the elaborate management agreements now found in the major timber producing provinces, and the dependence on private licensees to manage Crown forests. This examination leads to some conclusions about the characteristics of resource rights needed to advance the broad public interest more effectively.

RIGHTS TO TIMBER

The Canadian constitution, which divides governmental responsibilities between the federal and ten provincial governments, assigns legislative authority over most land and natural resources to the provinces. The federal government influences forest development indirectly, through its authority in matters of taxation, international trade and regional development, but responsibility for the way forests are managed and used falls mainly to provincial governments. Moreover, because all Canadian governments have adhered to a policy of retaining public ownership forest land throughout most of the present century, most forest land is actually owned by provincial governments. The exceptions are mainly land granted to private interests in earlier periods, concentrated in the earlier-settled eastern provinces.

Under their distinctive legislation and policies, provincial governments grant rights to timber. Over the years, various forms of rights to Crown land and timber have been designed to meet changing needs, and they carried various terms and conditions relating to such matters as their term and renewability, charges for timber, and stipulations about fire protection and harvesting.

During the past century, provincial governments have turned from granting outright title to forest land to leases, which give their holders broad exclusive rights during their term, and more recently to licenses, which are essentially contracts between the Crown and the licensees that convey no proprietary interest in the land. At the same time, as pressures on forests increased and demands for management grew, licenses have become more varied, sophisticated, and complicated. Special licenses have been devised to accommodate the needs of farmers, small logging operators, producers of special products, large sawmilling and pulp and paper enterprises and integrated operations.

Today, there are more than 30 forms of rights to Crown timber in Canada, ranging from longstanding leases to modern licenses and special-purpose permits (Haley and Luckert 1989). The main types are summarized in Table 1. In all the major timber producing provinces, rights to harvest Crown timber are issued within a general forest regulation framework based on sustained yield principles.

Management Agreements

Particularly distinctive are the sophisticated forest management agreements adopted by the major timber producing provinces to accommodate the long-term requirements of major forest products manufacturers, especially pulp and paper enterprises. The tenure contracts referred to here collectively as *management agreements* are found in nine provinces, indicated in Table 2, where they are given various names such as forest management licenses and tree farm licenses[1]. These management agreements typically cover large territories: last year one awarded in Alberta exceeded 73 thousand square kilometres - more than double the size of Belgium. Their terms are long, of 20 years or more, and in all cases they are either renewable when they expire or replaceable on an "evergreen" basis - that is, after only part of the term has expired, the license may be replaced with a new license, carrying the same term as the old one.

Some management agreements enable licensees to combine their private lands with contiguous Crown forest into a single management unit. In some provinces the terms and conditions of agreements are uniform; in others they are individually negotiated. Usually they require the holder to

Table 1 COMMON FORMS OF FOREST TENURE IN CANADA

form of tenure	usual size	usual holders	term	holder's forest management obligations
Freehold lands	varies widely from small parcels to extensive tracts	varies: small landowners to large timber companies	perpetual	all (subject to minor regulation)
Timber Leases	medium to very large tracts	timber companies, and investors	long and/or renewable	varies: usually modest
Management Agreements	very extensive	integrated forest products companies	long and renewable	almost all
Volume or Quota Licences	not defined	sawmilling companies	long: sometimes unlimited	varies:modest to substantial
Timber Sale Licenses	small tracts	logging and sawmilling companies	short	modest
Woodlot Licenses	very small lots	farmers and other rural property owners	long and renewable	almost all
Special Cutting Permits	small areas	roadbuilders, miners, and other developers	short	few

periodically prepare management and working plans which, when approved, become part of the agreement (Campbell and Pearse 1984). In almost all cases, the area covered by a management agreement is managed as a separate sustained yield unit with an approved allowable annual cut[2].

The conspicuous feature of these agreements is the balancing of the licensees' harvesting rights with management obligations. Usually, the licencee's rights are limited to his use of the forest for timber production, but this includes the exclusive right to harvest timber within the licensed area, (though some licenses allow for others to cut special products, to harvest timber the licensee fails to harvest, or to share the harvest in certain areas). In return for these rights to the timber, the agreements assign to their holders a wide range of responsibilities for managing the forest, including maintenance of forest inventories, forestry and development planning, road building and maintenance, forest protection, reforestation and other silvicultural activities. Virtually all the operational forest management in these licensed forests is done by licensees according to plans approved by the Crown forest agency.

Licensees are obliged to make certain payments to the Crown, including stumpage fees on the volume of timber harvested, payable as the timber is harvested, and in some cases an annual rental based on the area licensed. Often the licensees are reimbursed for expenditures on improvements such as roads and silviculture (discussed below). In most cases the licensee is obliged to operate a manufacturing plant as a condition of his license.

In the absence of opportunities to acquire freehold forest lands, these comprehensive forest management agreements have become the preferred form of tenure for much of Canada's forest industry. They are large, inexpensive to acquire, well suited to the needs and capabilities of large corporations and, on paper at least, secure. They are undoubtedly the most distinctive feature of the Canadian forest tenure system.

Forest management agreements have proven highly successful in encouraging investment in forest products manufacturing, which has been a major objective of provincial governments. Most new ventures involving substantial capital investments in recent years have been supported by these management agreements, demonstrating that their long terms, renewability and protection from competition are sufficient to provide the security of raw material supply needed by investors. Indeed, from the viewpoint of corporate investors, this form of rights to raw material has at least one significant advantage over freehold lands in being almost costless to acquire - the main charges for the timber being payable only when it is harvested.

Management agreements have had some success in advancing forest resource management as well. Though Canadian standards of forest management are often regarded as being rudimentary in comparison with practices in Europe and the United States, most observers agree that the Crown forest lands managed under these long-term management agreements are more carefully managed than most other Crown forests. However, as we observe below, management effort on these licensed lands tends to fall short of the effort on private lands.

Finally, these agreements accommodate the Canadian preference for keeping natural resources in the public domain without requiring a public service of the size capable of managing the vast Canadian forests directly. Forest management agreements muster the manpower and resources of licensees to the task of managing public forests, allowing the public service to concentrate on adjudication of plans, surveillance and enforcement.

These are significant advantages, and they account for much of the enthusiasm for this form of forest tenure among foresters, timber companies and governments. Some provinces have been expanding these arrangements for allocating Crown timber at the expense of other forms of licensing, and governments of other countries have adopted this Canadian model for private management of public forests[3].

Volume Licenses

The licenses referred to here as *volume licenses* are found in a variety of forms in seven provinces, as indicated in Table 2. They are primarily licenses to cut a specified volume of timber per year within a broad administrative area, the specific location of operations to be designated from time to time (the exceptions are the Ontario and Newfoundland versions, which define the licensed areas as well). In most cases licenses are issued for 10 to 20 years, and are renewable or replacable on an "evergreen" basis.

Because most of these volume licenses do not define a geographical area, they do not involve individual forest yield regulation except as part of a larger forest unit. Their management obligations are generally less demanding than those of management agreements, but they usually involve some roadbuilding, protection, basic reforestation and in most cases the maintenance of a manufacturing plant[4]. The trend in recent years has been toward greater management

Table 2 MAIN FORMS OF FOREST LICENSING IN THE CANADIAN PROVINCES

	Management agreements				Volume licenses			
Province	form of license	number	term years[a]	share of regulated harvest[b] %	form of license	number	term years[a]	share of regulated harvest[b] %
British Columbia	Tree Farm Licenses	40	25(10)	26	Forest Licenses	171	15(5)	56
Alberta	Forest Management Agreements	7	20(r)	25	Timber Licenses (Quotas)	143	20(r)	24
Saskatchewan	Forest Management License Agreements	5	20(5)[e]	93	Cutting Agreements	0		
Manitoba	Forest Management Licenses	2	20(r)	60	Timber Sale Agreements	408	<15(r)[h]	32
Ontario	Forest Management Agreements	30	20(5)	70	Order-in-Council Licenses	234	<20(r)[i]	26
Quebec	CAAF Agreements[c]	300 (approx.)	25(5)	100	(none)			
New Brunswick	Crown Timber Licenses	10	25(5)	73	Sub-Licenses	117	5(1)	27
Nova Scotia	License and Management Agreements	2	50(10)[f]	86	Utilization License Agreements	17	<10(r)	14
Newfoundland	Timber Licenses[d]	more than 100	99[g]	65	Short Term Timber Licenses	1	20(r)	10

Source: Adapted from Haley and Luckert (1989) Table 3 and miscellaneous sources.

[a] Numbers in brackets indicate the number of years into the term at which "evergreen"licenses may be replaced; (r)indicates that the license is renewable upon expiry of its term.

[b] The figures shown are the approved allowable annual cut under the agreements or licenses-expressed as a percentage of the total allowable annual cut authorized for harvesting on provincial Crown lands. In Alberta, 43 percent of the allowable annual cut is not yet committed.

[c] Contrat d'approvisionnement et d'amenagement forestier.

[d] Includes a single, extensive, Timber Lease.

[e] Older licenses have no "evergreen" provision but are renewable

[f] One agreement is not "evergreen", but is renewable for 40 years upon expiry of its first term.

[g] A few licenses have 25 or 50-year terms. The Timber Lease has a perpetual term.

[h] Term varies from one to 15 years, usually five, and is replacable.

[i] Term varies from one to 20 years, depending on the size of the licensee's mill, and is renewable for one year.

responsibilities of licensees.

Volume licenses, like management agreements, have obviously met the needs of an important segment of the forest industry. They are particularly suitable for the larger firms that combine logging and sawmilling; these are the major licensees, although pulp and paper companies, which often hold management agreements as well, have become important holders of volume licenses, mainly through aquisition of smaller firms.

INCENTIVES FOR MANAGEMENT

However, management agreements and volume licenses have attracted criticism from several quarters. One concern is that they may aggravate the strong trend toward concentration of the Canadian forest industry into fewer, larger corporations, which leads to regional monopolization of resource rights, barriers to new entrants and inefficient resource allocation (Schwindt 1979).

Several features of these dominant forms of licenses encourage these trends: they are tailored to the needs of relatively large forest enterprises and are generally more favourable in terms of their security, duration and protection from competition than the timber rights available to small, specialized and unintegrated forestry enterprises; they are usually available only to firms that integrate forestry and manufacturing; they are granted without competition; and although they are not usually divisible they can be transferred and amalgamated[5]. Moreover, the available timber supply in most developed regions is fully allocated, leaving no room for new enterprises, except by purchasing rights from an established company or merging with it.

This bias in the tenure system is aggravated by the absence of price competition among applicants in the allocation of timber rights (in sharp contrast to general practice in the United States). Instead, provincial governments depend on bilateral negotiations with companies, which leaves no market mechanism to ensure that the available timber is distributed to the most efficient users, or to provide opportunities for new entrants.

A second concern is about the adequacy of payments for public timber under these licensing arrangements. Because timber rights are rarely allocated by competitive bidding, there is little direct market evidence of their worth, and critics argue that the administered stumpage prices charged for timber harvested fall short of its real value (Haley

1980). This was the grounds for the recent U.S. countervailing tariff on Canadian softwood lumber, which led to sharp increases in stumpage rates in major producing provinces.

A third concern, of special interest here, is about the adequacy of silviculture in licensed forests and, more specifically, about weak incentives to invest in forest enhancement where the managers are private enterprises and the resources are public property (Pearse 1985). A recent survey of seven Canadian provinces found that licensees have little incentive to invest in silviculture beyond their contractual requirements, and that the silvicultural effort on licensed Crown lands falls significantly short of the effort on similar private lands (Luckert and Haley 1990). This meagre attention to silviculture in Crown forests is alleged to result in foregone opportunities, waste of public resources and the threat of inadequate timber supplies for the future (Reed 1986).

Provincial governments have devised a variety of techniques to promote silviculture on licensed lands, none of which has proven to be entirely satisfactory. All licenses impose some *contractual obligations* on the licensee, which he must fulfill at his own expense or suffer penalties. This regulatory approach is often used to ensure basic silvicultural practices, such as reforestation after logging, but it is not sufficiently discriminating to provide for intensive silvicultural treatments appropriate to differing forest sites. As long as licensees must absorb the cost, and the Crown claims the equity in the enhanced timber, license holders find their financial interest lies in restricting their efforts to the minimum required by their license contracts.

Most provinces *reimburse costs* incurred by holders of forest management agreements for silvicultural work done on Crown land, or reduce the licensees' costs by providing seedlings and other requirements without charge[6]. This reduces the disincentive to undertake such activities, but it provides no positive incentive for silvicultural effort.

Four provincial governments offer holders of management agreements silvicultural incentives in the form of *increases in approved harvest rates* in recognition of voluntary silviculture that increases timber yields. To sharpen the incentive, demonstrated increases in growth carry *reduced stumpage charges* in Ontario, and in Alberta they are free (Haley and Luckert 1989). However, even these harvest incentives have not stimulated much voluntary silvicultural spending. Moreover, the formulae used to fix regulated harvest rates produce the "allowable cut effect", which means that increases in the allowable harvest depends more on the inventory of the regulated forest than on the real impact of the silviculture itself, or its cost, thus distorting the distribution of silvicultural effort (Bell *et al* 1975; Binkley 1980).

A considerable variety of other techniques for promoting silviculture on Crown lands have been proposed, ranging from conventional subsidies, tax incentives and entitlements to greater harvest rates to elaborate schemes for rewarding silviculture through share-cropping, warrants against timber in the future, and silvicultural or stewardship contracts as adjuncts to licensing arrangements (Boulter 1984; Luckert and Haley 1989; Olivotto 1987). However, as explained below, none of these appears likely to overcome the fundamental problem of perceived insecurity and uncertainty associated with long-term contractual arrangements with provincial governments, which underlies the reluctance to invest in silviculture.

A fourth concern is about the recognition of forest values ther than timber, and efficient land allocation among uses and combinations of uses. Because the needs of wildlife, recreation and other values often conflict with timber production, compromises must be made to achieve optimum patterns of resource use. But where the manager is a private enterprise whose rights extend only to industrial use of the timber, his incentive to manage for other values is weak. All this puts a heavy burden on regulatory arrangements and the agencies responsible for supervising forest plans and operations, and the results are often contentious. To aggravate this problem, timber is typically the only forest product that is commercially traded and valued in market prices, presenting a major analytical problem in determining the highest use or combination of land uses (Bowes and Krutilla 1989).

These last two problems - the weak incentives for silvicultural improvement of licensed Crown lands, and the difficulty of balancing non-commercial values against timber benefits - are serious and growing obstacles to efficient forestry development in Canada. They can be expected to put increasing pressure on the regulatory framework and on policy-makers.

Both problems raise fundamental questions about the structure of property rights in forests. Holders of forest agreements and licenses on Crown lands decline silvicultural opportunities because their rights do not provide sufficient assurance that the benefits will accrue to them. In contrast to freeholders who can expect to capture all the benefits of their efforts, licensees are restricted in terms of the kind of benefits they can enjoy, the time over which they can enjoy them, and the extent to which they must share economic gains with the Crown. Moreover, notwithstanding the apparent security afforded by the long terms and provisions for renewal and replacement in volume licenses and management agreements, licensees perceive their rights as being insecure (Luckert and Haley 1989). Provincial governments have repeatedly resorted to legislation to abolish, curtail or alter outstanding rights to Crown timber, leaving license holders apprehensive about political intervention that might obliterate returns on their silvicultural effort. Clearly, if private enterprises are to be effective stewards of Crown forests, their rights must be strengthened so that their perceived financial advantage is more consistent with the public interest in forest enhancement.

Similarly, the non-timber forest resources most in danger of neglect and degradation are those over which property rights are weakest, such as water, fisheries, and wildlife. These are usually common property, protected only by regulatory restraints on users. It is therefore to be expected that, when they conflict with resource uses driven by economic interests supported with firmly vested property rights, they will suffer. Our present structure of rights is thus biased against the so-called environmental resources.

All this suggests that policy-makers should focus their attention on the character of the rights under which the forests are used and managed. Recent literature on this subject suggests that in order to channel incentives to use and develop resources most efficiently the rights of users must have certain essential characteristics. They must be *exclusive*, so that each holder can exercise his rights without interference from others; *beneficial* entirely to the holder, so that his incentive to manage and use resources to maximum advantage is not blunted by charges or restrictions on his returns; sufficient in *duration* to ensure that he can realize the future benefits of management effort; *divisible and transferable* so he can reallocate resources to higher uses and users as circumstances change; and *secure*, so that his incentive to use resources efficiently is not undermined by uncertainty about any of these elements or their enforceability against third parties (Randall 1975).

Forest management agreements and most volume licenses provide the desired exclusivity, but on all the other criteria they fall well short of the theoretical ideal. The evidence referred to earlier suggests that the combined shortcomings cause licensees to balk at long-term investments in forest productivity.

THE PROBLEM OF SECURITY OF RIGHTS

Most fundamental is the underlying quality and security of the property rights. The security afforded by even long-term management agreements is inadequate to induce licensees to voluntarily invest in silviculture on their licensed Crown lands. As noted earlier, anxieties about the security of licenses are supported by historical experience, and surveys of licence holders show that they regard their licenses as much less secure than their private holdings. As a result, their voluntary silvicultural spending per hectare on Crown lands under management agreements is low, and in British Columbia it averages less than one-quarter the amount spent by the same companies as their private forest land (Luckert and Haley 1989).

It can reasonably be assumed that the level of silvicultural effort needed to generate maximum long-run returns on Crown forest land is at least as great as the amount private owners voluntarily undertake on similar land. This suggests that the present silvicultural effort on Crown land in Canada falls well short of the optimum, and the cost in forestry opportunities foregone is likely to be considerable.

To the extent that governments continue to depend on private licensees for silviculture on Crown lands, the task facing policy-makers is to overcome the deterrent to investment in future crops arising from the perceived insecurity of existing licenses. It follows that the most promising way to stimulate appropriate silvicultural effort may be to provide the private managers with a stronger, more secure, interest in the resulting benefits.

The insecurity of licenses arises from the inherently weak legal claim of a license-holder. A license is no more than a contractual undertaking between the licensor and licensee; it implies no proprietary interest in the land and it is not enforceable against third parties. Moreover, in the present context the licensor is the government, which can over-rule such undertakings (with legislation if necessary) leaving the licensee with little recourse.

Property law suggests a variety of legal arrangements capable of providing greater security and hence stronger interest in resource enhancement than a license[7]. For example, even with the Crown retaining ownership of the land, it is possible to create a separate proprietary interest in the land's forest production which has the quality of a fee simple interest (Megarry and Wade 1966). By providing legal security, comparable to that of private ownership, such arrangements would go a long way toward ensuring comparable incentives for forest management[8]. And, with careful attention to their design, they can incorporate all the other characteristics of property rights, noted earlier, that promote efficient management and use (Pearse 1990). Such revisions of the tenure system seem more promising means of improving forest management than new fiscal incentives or supplementary contractual arrangements for silviculture.

Indeed, rights to other resources such as water, fisheries and wildlife can be devised with the same essential features; Britain and Europe are particularly rich in property rights of this kind. Stratified proprietary interests over resources within the same area present further opportunities for directing private incentives toward integrated resource management. Such arrangements allow the value of each resource to be reflected in the market value of the rights to it, generating incentives to protect and enhance its productivity, and at the same time they facilitate transactions in rights as a means of resolving conflicts among competing resource interests.

CONCLUSION

The range of choice in designing rights to timber in Canada is constrained by the need to reconcile public ownership with private use and development of land and resources. Historical efforts to harmonize these public and private interests are reflected in the variety of timber licensing systems, designed increasingly to encourage private licensees to take responsibility for developing public forests. However, as the era of exploiting natural timber draws to its inevitable end, forcing attention to the husbanding of new crops, present licensing arrangements are proving inadequate, especially with respect to the long-term security of rights private investors need to support voluntary investment in silviculture. This suggests a need for renewed attention to the tenure systems that regulate the forest industry's activities on public lands. Specifically, it suggests a need for innovations in property rights to provide those depended upon to initiate forest improvements with a stronger proprietary interest in the crops they manage.

FOOTNOTES

[1] The only province with no counterpart of the management agreement is Prince Edward Island which contains only 2,500 square kilometres of forest, 95 percent of which is in small private holdings.

[2] This brief sketch of the terms and conditions of management agreements ignores many exceptions and special arrangments in particular provinces. For a more detailed account, see Haley and Luckert (1989).

[3] The U.S. Forest Service entered into one such agreement covering a large tract of national forest on the Olympic Penninsula of the State of Washington. Among other developing countries, Kenya has recently adopted a forest tenure system patterned on British Columbia's tree farm license. The same model is currently under consideration in Tasmania.

[4] In New Brunswick, sub-licenses are issued within areas covered by Crown Timber Licenses, the holders of which are responsible for most management functions. In Saskatchewan and Ontario the provincial forest service takes responsibility for reforestation.

[5] In most cases, transfers require the consent of the Minister responsible for issuing the licenses, which is usually granted (Haley and Luckert 1989).

[6] Licensees are required to bear the full cost of reforestation only in Alberta and British Columbia (Haley and Luckert 1989).

[7] A license does not convey a proprietory interest in the land, it does not "run with the land", and it is not enforceable against third parties, in contrast to a lease which can convey full rights of possession for a limited term, or a *profit a prendre* which can convey rights to the beneficial use of some attribute of the land with all the legal characteristics of an estate and without limitation of term (Megarry and Wade 1966).

[8] In New Zealand, plans for the outright sale of Crown forest land were recently abandoned, apparently in deference to Maori land claims, and rights to the forest, only, are being sold. This appears to provide proprietary interests in forest production of the kind suggested here, though the New Zealand rights are limited in duration (New Zealand Forestry Corporation 1989).

LITERATURE CITED

Bell, Enock, Roger Fight and Robert Randall. 1975. ACE: The two-edged sword. *Journal of Forestry* 73(10):642-43.

Binkley, Clark S. 1980. Economic analysis of the allowable cut effect. *Forest Science* 26(4): 633-42.

Boulter, D.W.K. 1984. *Taxation and the Forestry Sector in Canada.* Information Report E-X-33. Canadian Forestry Service Environment Canada. 113pp.

Bowes, Michael D., and John V. Krutilla. 1989. *Multiple-Use Management: The Economics of Public Forestlands.* Washington, D.C.: Resources for the Future.

Campbell, Richard S., and Peter H. Pearse. 1984. Policy instruments for reconciling competing demands on public forest land. In *Policy Analysis for Forestry Development*. Proceedings of the Conference of the International Union of Forestry Research Organizations, (Division 4) in Thessaloniki, Greece, August 27-31, 1984. Vol. II, pp. 13-20.

Haley, David. 1980. A regional comparison of stumpage values in B.C. and the U.S. Pacific Northwest. *Forestry Chronicle.* 56(5): 125-31.

Haley, David and Martin Luckert. 1989. *Forest Tenures in Canada: A Framework for Policy Analysis.* Report prepared for Forestry Canada, Economics Branch, Ottawa 119pp.

Luckert, Martin K. and David Haley. 1989. *Funding Mechanisms for Silviculture on Crown Land: Status, Problems and Recommendations for British Columbia.* Working Paper 131-A. Forest Economics and Policy Analysis Research Unit. University of British Columbia. 59pp.

_________ 1990. The implications of various silvicultural funding arrangments for privately managed public forest land in Canada (forthcoming in *New Forests*).

Megarry, R.E. and Wade, H.W.R. 1966. *The Law of Real Property.* 3rd Edition, London, Stevens and Sons.

New Zealand Forestry Corporation 1989. *Sale of State Owned Forests in New Zealand:* Prospectus. Wellington, New Zealand Forestry Corporation Limited. 65 pp.

Olivotto, Giuseppe G. 1987. *Finance For Intensive Silviculture in British Columbia.* Unpublished M.Sc thesis. University of British Columbia, Vancouver.

Pearse, Peter H. 1990. *Introduction to Forestry Economics.* University of British Columbia Press, Vancouver.

_________ 1985. Obstacles to silviculture in Canada. *Forestry Chronicle.* April: 91-96.

Randall, Alan. 1975. Property rights and social microeconomics. *Natural Resources Journal* 15 (October): 729-47.

Literature Cited, continued

Reed, F.L.C., 1986. Canada's timber supply. *Forestry Chronicle* August: 335-338.

Schwindt, R. 1979. The Pearse Commission and the industrial organization of the British Columbia forest industry. *B.C. Studies* 41 (Spring 1979) pp.3-35.

PROPOSED ECONOMIC AND ECOLOGICAL PRIORITIES IN FOREST UTILIZATION AND REPRODUCTION FOR THE USSR

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The efficiency of forest utilization and reproduction greatly depends on economic relations between the State and forestry enterprises under different forms of land ownership. There are three systems of such relations in the world experience of forest industries and forestry development and organization.

1. Centralized planned economy (the USSR and other socialist countries). Almost all forests belong to the State. Forest monitoring is carried out by the State organizations which are at the same time responsible for cutting, growing and protecting the forests. The centralized financial resources are allocated by regions and forest industries, following the goal to gain maximum economic effect during the nearest period without due regard for ecological and social conditions. Forestry development financing is derived from the State budget irrespective of the efficiency of forest utilization and growing.

2. Market economy at the early stage of capitalist relations development. Forests were cut by private enterprises to gain maximum profit, no monitoring of the forests was carried out by the State.

3. Regulated economy. Forest management and utilization functions are shared among the State and enterprises in the following way:

   - The State is responsible for forest resources management, determining the allowable cut, developing silvicultural programs based on taxation, stumpage rates, leasing fees, land rent, bank interest, budget subsidies and penalties.
   - Enterprises set up their own production programs and investments into technical development with due regard for ecological and social demands, as well as market prices.
   - At the same time, the enterprise is responsible for forest growing and protection and reforestation programs development under the supervision of the State bodies.

The economic relations in forestry are regulated by the State in Canada, Finland, Sweden and other countries which have succeeded in rational use of forest resources, observing the economic, ecological and social priorities.

The economic reforms in the USSR are also aimed at harmonization of the State interests and the interests of different regions and enterprises (State, leasing and cooperative ones) in forest use and reproduction. All decisions in forestry should be thoroughly estimated to define their influence on the volume of cutting, forest products demand and supply, and environmental conservation. In capitalist countries, there are the following economic indicators to estimate the efficiency of silvicultural and harvesting programs:

- prices for roundwood and wood products,
- stumpage rates,
- forest rent and land rent,
- penalties for environmental pollution and ecological function abuse.

The methods of economic estimation of decisions in forestry based on the above-mentioned criteria are well-known in the regulated economy. But it takes a rather long period of time to introduce these methods and principles in USSR forestry because this process is closely connected with the general economic reforms in the country as well as with the influence of many other factors, e.g. it took almost 20 years to introduce the regulated economy in the forestry of Hungary.

Analyzing the results of forest harvesting and growing by regions of the USSR, one could notice that in many cases, there were not thoroughly estimated programs for logging and silviculture. This considerably reduced the efficiency of forest resource use. So both short- and long-term programs are needed to normalize the allowable cuts and reforestation using economic and ecological criteria.

To take into account the great difference in silvicultural, natural and economic conditions of forest harvesting and growing by regions, we should use a new approach to economic efficiency calculation based on input-output models for different forest types including such characteristics as soil type, main species, age class, etc.

It is suggested that normative input-output information should be obtained for all forest types before making any decision on harvesting, reforestation, and forest protection.

Regional economic and ecological priorities are calculated:

$$Q_r = \sum_i YiLi \qquad (1)$$

where Q_r = regional priority to harvest and grow forest resources,
i = number of forest types,
Yi = priority indicator by forest type i,
Li = the share of forest type i in the whole forest area.

The priority indicators are determined for:

a) forest resource utilization where roundwood and wildlife products (mushrooms, berries, animals, etc.) are considered to be final outputs,

b) forest reproduction where newly regenerated young forest stands at a definite age are regarded as final outputs,

c) timber products transportation to consumers that determines the transport accessibility of forest resources on the basis of costs,

d) the part played by forest resources in formation and support of natural ecological systems where ecological effects are regarded as final goals.

All the above-mentioned priorities are distinguished by the efficiency criteria based on the input-output analysis. Let us consider these criteria. The efficiency of forest resources utilization is estimated by normative profit per ha of the area covered with forest, resulting from the roundwood and wildlife products sales.

$$P = R - C \qquad (2)$$

where P = normative profit from roundwood and wildlife products sale,
R = sold output in current prices,
C = direct and indirect costs to harvest timber and wildlife products without stumpage value and other fees for natural resources.

Since the conditions of forest resources utilization are different, the sold output and harvesting costs depend on many factors. These relations may be interpreted by the following expressions:

$$R = f(x_1, x_2, x_3 \ldots x_n) \qquad (3)$$

$$C = f(y_1, y_2, y_3 \ldots y_n) \qquad (4)$$

where $x_1, x_2 \ldots x_n$ = factors determining the value of sold output per ha (site index, species composition, age class, demand and supply for wood and wildlife products in the internal and world market), $y_1, y_2 \ldots y_n$ = factors determining the direct costs to harvest forest resources (species composition, stock per ha, mean volume of a tree, soil characteristics).

The input-output models are developed for technological processes differing in machinery systems, labor mechanization, and forms of cutting. Direct costs of harvesting include:

- wages with insurance charge,
- depreciation,
- fuel and energy costs,
- maintenance costs.

Indirect costs are calculated in relation to the direct ones. Thus, the conditions of forest resources harvesting may be expressed by the following general formula:

$$P = f(x,y) \tag{5}$$

One can choose an effective harvesting policy through comparing normative profits; harvesting conditions are best if the profit has its maximum value.

As for the efficiency criteria of forest resources reproduction (regeneration, growing), one of them may be also the normative profit where new young forest stands are sold to the State at a definite age (t). It is possible to apply this approach to efficiency calculation because the existing system of budget financing in forestry was replaced by cost accounting. So the normative profit in forest growing is calculated as a difference between the sold output represented by naturally or artificially regenerated areas and the silvicultural costs.

As the inputs and outputs of forest growing do not coincide in time, revenues and costs should be discounted, with inflation rates taken into consideration.

$$E = QK_1 - WK_2 \tag{6}$$

where E = normative profit per ha from the silvicultural output sale (regenerated areas, thinned areas, etc.)
Q = sold forestry output in the prices fixed in the beginning of forest growing,
W = direct and indirect silvicultural costs to grow a forest stand to age t,
K_1 = inflation factor, including the difference in time (t),
K_2 = discounting factor.

The forest growing normative profit depends on many factors:

$$E = f(z_1, z_2, z_3 \ldots z_n) \tag{7}$$

where $z_1, z_2, z_3 \ldots z_n$ = factors (species composition, age class, machinery and technology, site index, etc.)

Direct silvicultural costs are calculated by the same methods as for harvesting, they include wages, depreciation, energy and fuel, maintenance costs, insurance fund to compensate for losses occurring due to environmental factors (fires, animals, insects, etc.). Thus, each forest type may be estimated by the normative profit resulting from forest regeneration and growing.

Comparing the economic results of forest utilization (P) and reproduction (E), one can develop an effective policy of multiple-use forest management, harmonizing the silvicultural and industrial interests. Such a policy may be achieved if the integrated normative profit is maximized:

$$P + E \dashrightarrow \max \tag{8}$$

The integrated normative profit represents the economic priority to harvest and reproduce forest resources of any forest type and in any region if the conditions, presented as parameters x, y and z, are known. The higher the integrated profit (P + E) values of forest areas are, the more economically accessible they are for industrial and silvicultural activity.

But in the USSR, it is not sufficient to apply the criteria, based only on the input-output analysis of harvesting and forest growing. It is necessary to take into account the transport factor, as well. The point is that wood and wood products must be transported long distances to satisfy the demands of consumers located where timber is scarce. Therefore, the transport accessibility of wood is defined by its hauling distance. To establish the hauling distances, the location and structure of the industry should be optimized on the national and regional levels. In the Union republics and regions, the transfer to the regional cost accounting should be based on the single transport network because all the railways and rivers are under All-Union State ownership.

Therefore, the criterion of transport accessibility of forest resources is transport costs, determined as follows:

$$T = f(l) \qquad (9)$$

where T = transport costs to deliver the roundwood to the location of consumption,
l = distance of transport determined by an optimal location plan.

In the USSR, where the mean distance of roundwood transport amounts to 1840 km, transport costs account for the significant change in the economic priority of forest resources utilization:

$$Q_s = P + E - T \qquad (10)$$

where Q_s = integrated national effect, roubles/ha.

The most complicated problem is to define the ecological efficiency of forest resources utilization. At present, forest economics does not provide any comprehensive approaches to calculating the ecological losses caused by forest cutting.

The potential ecological losses are usually prevented by administrative methods, using different restrictions (allowable cuts, protective forests). The problem is that ecological implications, resulting from irrational forest resources utilization, reveal themselves only in the distant future. Therefore, to establish the ecological priority, the prevented ecological losses should be known. These losses are calculated on the basis of the inputs intended for compensating the negative effects of forest cuttings.

If the inputs to prevent ecological losses are known, the criterion of ecological efficiency is estimated as follows:

$$N = K\ E_n \qquad (11)$$

where N = indicator of the ecological priority that shows the possible profit reduction in the national economy if the capital investments are directed to compensation of ecological losses,
K = capital investments, directed to prevention of negative effects of irrational forest use,
E_n= normative factor of capital investments' economic efficiency.

The forest areas where clearcutting causes grave disturbances of ecological functions (mountains and permafrost areas) are characterized by higher values of N.

Comparing the economic and ecological criteria allows one to derive the integrated priority, harmonizing the economic and ecological results and interests:

$$Q_{in} = P + E - T - N \qquad (12)$$

where Q_{in} = integrated priority.

The integrated priority should be established for all forest areas and all forest regions in order to organize forest management based on short- and long-term planning. The regional programs are needed to regulate forest cuttings, finance forestry activities, and allocate forest industries.

As shown in Figure 1, calculation of the ecological and economic priorities by forest areas requires much normative information (expressions 3, 4, 7, 9, 11) that will be used in the future to evaluate forest lands and, thus, defend the interests of forestry in the national economy.

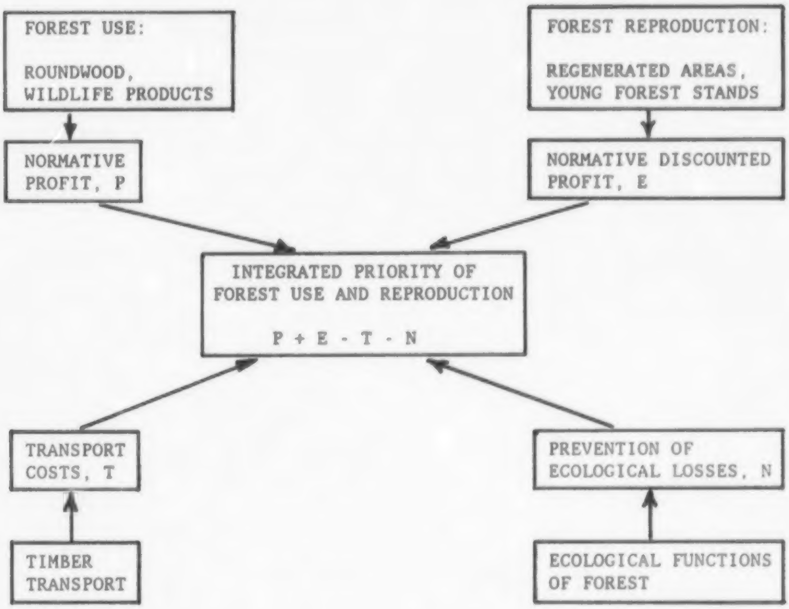
FOREST USE:
ROUNDWOOD, WILDLIFE PRODUCTS
FOREST REPRODUCTION:
REGENERATED AREAS, YOUNG FOREST STANDS
NORMATIVE PROFIT, P
NORMATIVE DISCOUNTED PROFIT, E
INTEGRATED PRIORITY OF FOREST USE AND REPRODUCTION
P + E - T - N
TRANSPORT COSTS, T
PREVENTION OF ECOLOGICAL LOSSES, N
TIMBER TRANSPORT
ECOLOGICAL FUNCTIONS OF FOREST

Figure 1: Economic and ecological priorities in forest use and reproduction.

FOREST POLICY CHALLENGES IN FORMATTING MANAGEMENT GUIDELINES IN CENTRAL EUROPE

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SUMMARY

The rehabilitation of central european forests changed their composition, increased their timber production but impaired their stability and social services. Today the public expects a forest management which preserves biotopes and their species diversity, conserves water resources and protection functions and opens possibilities for recreation. Forest owners set the production of timber with large dimensions and high quality as their management objective. Only a management using stable stand compositions and long rotations, avoiding clearcutting and minimizing the input of extraneous energy can fulfill such expectations. The challenges of a management under such guidelines for forest policy are discussed.

Keywords: Forest policy, social services, legal measures, public aid.

INTRODUCTION

Central Europe is a term quite frequently used but rarely defined. It is not a political, more a geographical, better a cultural entity. Central Europe comprises the center-part of continental Europe. For the last 40 years its states belonged to different political systems with widely varying economic and social situations and circumstances. East of the perforated "iron curtain" are states and societies right now in a revolutionary process to a new European order. Wether the central European states belong to the "western" or "eastern" political powers they have in common their high population densities, their high degree of industrialization and their actual problems of land-use and -management.

By nature Central Europe would be heavily wooded by cool temperate mixed hardwood-, oack- scotchpine- and mountainous conifer-forests. In general deciduous trees would dominate that forests clearly. Over the last 7 to 8ooo years around two third of the forest area was cleared for other types of land-use, mainly for agriculture. Thereby the most productive sites were lost. The remaining forests were utilized and managed since long. On most areas was their composition, structures and productivity more or less changed thereby. All central European forests are therefore man-made.

Independent of political and economic systems is central European forestry in a phase of orientation towards new goals and objectives. The public or social services of forests grew and still grow in importanace. To bring them in goal-harmony or goal-neutrality with the goals of forest owners, at least to find acceptable compromises between public and individual interests is a demanding challenge for forest policy.

HISTORICAL REVIEW OF MANAGEMENT PRINCIPLES

At the beginning of the 19th century was the bulk of central European forest in a poor state after one and a half centuries of overcutting, overgrazing and overracking. To ensure the timber supply, to reach a profitable forestry and to guarantee the protection-functions of forests it was necessary to rehabilitate the devastated forests. Huge areas of coppice forests had to be converted into high forests, unstocked or understocked areas had to be reforested and idle land had to be afforested.

The economies of the central European states followed already the classical economic theory. Forest science applied it to forest-economics as well. The ideal forest model and the formulas to calculate the species with the highest monetary return and the financial rotation with the highest rate of interest on the capital invested were developed. A forest management under that concept fit perfectly with the liberal economic theory, which set the maximization of profit as the general objective of economic activities. Thus the so called soil rent theory became the guideline for the concept of forestry in the 1800's. The consequences for practical forestry were obvious. The capacity of a species to grow rigorously in its youth gives it an advantage over the slow starters. The pioneers win the game against the climax species. In Central Europe the pioneers mainly used were Norway Spruce and Scotch Pine. They had besides the adventage to be hardy species, which could easily be seeded or planted on open land. If the application of the soil rent theory is followed to its logical end, all the existing forest stands that do not meet the expected interest rate would have to be cut and replaced by better producing ones without consideration of age-class distribution or even flow of products. As long as the land produces timber is the principle of sustained yield observed.

The rehabilitation of central European forests was achieved under such liberalistic economic principles. The coppice and coppice with standard forests, composed of the natural hardwood species, and occupiing huge areas, were cleared away and replaced by conifer-plantations. Deciduous high forests were converted by seeding and planting into softwood monocultures. Rotations were shortened, natural regeneration replaced by artificial one, selection or shelterwood-systems by clearcutting.

Criticisme against the soil rent theory arose already shortly after it was developed and applied. A long and heated conflict was fought between the advocates of the soil-rent- and the so called forest-rent-theory. The later claimed a forest management according to the soil-rent-theory would impair the soil productivity and therewith the principles of sustained yield, would neglect the production of social goods and services and therewith the public interest and would harm the stability and resistance of forests against biotic and abiotic threats and therewith lead to damages outweighting the expected monetary advantages by far. The academic conflicts about the theories could not prevent that the ideas and the principles of the soil rent theory had a deep and lasting impact on central European forestry.

The success of the rehabilitation work was astonishing. Already at the turn of the 19th to the 20 th century was a more or less even age-class-distribution achieved, had the standing volume been raised and the running increment doubled and even trippled. The price, which had to be paid for such a remarkable result, was a fundamental change in the forest composition. The natural broadleave species were pushed back and substituted by softwood-species. On large areas were naturally mixed forests turned into conifer-monocultures. According to the level of knowledge of the time species were not seldom chosen, and provenances used, which did not fit to the sites. From what we know today the consequences were not surprising. The damages caused by storm, snow, fire, fungi and insects increased rapidly and reached levels unheard up to than. The risk of unplanned or forced cuts, which grew remarkably with the time, reached a level that made decisious unavidable. Central European forestry had basically two choices: Either to turn to a true plantation forestry using all tools of modern technology or to turn back to a more ecological oriented concept of forestry.

SOCICAL EXPECTATIONS ON FOREST MANAGEMENT

Forest have to produce a number of social services. ODUM claimed that the human or nonbiological systems with their urban-industrial environment depend for their life support on three types of biological systems:

1) Mature systems as a protective life support environment. They have to "stabilize substrates, buffer air and water cycles, and moderate extremes in temperature and other physical factors, while at the same time often provide products."

2) Growth systems as a productive life support environment. They can be "croplands, pastures, tree plantations, and intensively managed forests that provide food and fiber."

3) Dissipative systems as a waste assimilative environment "assimilating the vast wastes produced by the urban industrial and agricultural systems."

Central Europe belongs to the most densely populated and most highly industrialized regions of the globe with a great concentration of non-biological systems on the one hand and large amounts of growth systems of intensively managed agricultural lands and forests on the other. The percentage of mature and of dissipative systems on the total area of Central Europe are against it astonishingly small. Only forests under an ecological oriented management can fulfill or can be developed to fulfill the functions of mature systems. Over the last three decades the public in Central Europe became more and more aware that mature forest systems could not be reached under a management triing to maximize the rate of interest on the capital invested. Public concern concentrated thereby mainly on four fields of forest-management.

The future water supply for human use, the preservation of biotopes and species of flora and fauna, the conservation of protection functions of forests and the possibilities of forest recreation. With a progressive contamination of groundwater resources under agricultural land through nitrates and biocides do forests become of increasing importance for the protection of groundwater resources and their refillment. Forest management is therefore expected to avoid large clearcuttings, intensive fertilization or application of biocides as the compaction of forest soils through the use of heavy machinery. The deep changes in forest-composition and structure over the last two centuries are made responsible for the eXtinction or endangering of many species of flora and fauna. Forest management is therefore expected to place at least three percent of the forest area under strict preservation and manage the rest as "mature" systems with long rotations, natural regeneration and the conservation of a sufficient amount of remaining dead timber. Growth of population and with it of settlement industries and infrastructure increased as well the area of protection-forests as the importance of their functions against erosion, avelanches and floods. It is known that the protection capacities of forests depend mainly on their high basal areas for indefinite periods. Naturally composed forests under selection or group-selection management reach such objectives best. Central Europeans use their forests intensively for recreation purposes. All forest-land is open for public use. Experience tells that the suitability of forests for recreation improves with growing age, diversity of composition and structure, the frequent occurence of edge-effects and the penetrability for visitors.

FOREST MANAGEMENT GUIDELINES FOR CENTRAL EUROPE

Not only the public but forestry itself became unsatisfied with the results of the management. Stagnating timber prices, sky rocking personal costs and increasing environmental restrictions led to tumbling profits and made it more and more difficult to brak even. Forest owners had to realize that central European forestry can not compete with standard quality timber on fully liberalized national and international timber markets. Forests in warm temperate and tropical climates can produce more fiber per area unit and year and it can be grown cheaper than here. And even in boreal forests can in spite of the lower productivity timber be produced cheaper on account of the lower social and environmental restrictions. The future of central European forestry can therefore never depend on the production of timber of staple commodity. It is a widely accepted fact in forestry circles that the economic survival will depend on the production of timber with large dimensions and high quality. Such timber can be grown under the given site conditions, the favourable age-class-structure and the professional skill of the managers. Central European forestry has to shoot not for the highest volume increment but for the highest value production.

Between the public and the forestry community it is thereby undisputed that forests in Central Europe have to produce goods and services on the same area. They have therefore to be managed under a multiple-use-concept. The product mix for each management unit can vary widely and has to be planned individually according to biological, social and economic parameters. In spite of such variations general management guidelines for Central Europe can be drawn up to meet public and industrial interests in the forests:

- stand compositions possibly following the potential natural climax for stability;

- rotations oriented at the highest value production,

- use of shelterwood-, group-cutting - or selection systems for regeneration and thereby avoiding clearcutting where possible,

- no application of herbicides, rarely of insecticides and fertilizers,

- no soil compaction through wrong mechanization of operations within the forest stands.

The general management guidelines comprise a concept of forestry trying to combine ecological and environmental aspects with public and private interests. Their implementation has started already to a different degree in states east and west of the iron-curtain. It started a conversion process of central European forests whose completion will need decades or even a century. It will only be successful if forest policy measures support and assist it in a proper way.

FOREST POLICY CHALLENGES

Challenges for forest policy to implement the new general concept of forestry are given in a wide variety of policy fields. Two main obstacles hampering the efficient persuance belong rather to environmental policies: the forest decline and the overpopulations of ungulates.

The forests in Central Europe are besides the ones in the United Kingdom the most heavily stricken by forest decline. Especially forests in the middle European mountain ranges, the Harz mountains or the Black Forests are on large areas already dead or dying. In the Alps frightful many trees show clear symptoms of decline. Over the last three years the decline symptoms of deciduous trees increased rapidly and brought hardwood forests in a critical condition without clear signs for the cause-effect-chains. The regional pattern of damage intensity shows a distinct increase from the north to the south, the west to the east and the lowlands to higher elevations. In scientific circles is little doubt that such decline symptoms are directly connected to air pollution.

Besides the decline symptoms on trees scientists are more and more concerned about the effects of acid depositions on soils and ground water resources. A growing member of research findings strengthen the apprehension that in the long run the consequences of the deposition might be as severe or even a more severe danger than forest decline itself.

There is no doubt that over the last five years the national and international efforts to reduce SO2-emissions were rather successful. There is no doubt as well that they were not yet successful enough and not successful at all in lowering NOx-emissions. If effective policy measures will not be found soon to reduce the emissions of SO2, NOx and organic compounds to an acceptable and technically possible level a successful implementation of the management guidelines can not be expected.

To high populations of ungulates are found all over Central Europe with rare exceptions independent from political and social circumstances. Their browsing effect prevents the realization of silvicultural goals through the elimination of a wide variety of tree-species. Fencing can only be an unsecure and very costly expedient for restricted areas. As long as parliaments and governments are not willing or not able to controll successfully the herds of ungulates the management guidelines will have no chance to be achieved in the field.

In the original sphere of forest policy it is primarily a question of legal measures to meet the challenge. All states in Central Europe have a forest-legislation amended in the last decades. All that laws open in one way or the other the possibility th bring forest areas under a special legal status. Forests, which have to serve special social functions, may it be nature preservation, erosion-protection, watershed-protection or recreation can be declared as preservation-, protection- or recreation-forests. In a declared or reserved forest can management activities be ordered, forbidden or even carried out by public agencies which are held necessary to produce the wanted public services in the optimal way. The possibility to order or forbid management activities raises the question wether such a declaration would not be an act of expropriation or at least be in its effect equal to it. The prevailing legal opinion rates the act of declaration not as an expropriation but admits the necessity of a compensation if orders or bans lead to higher management costs against a normal and unregulated management.

In the free and democratic states of Central Europe the question was discussed with increasing intensity over the last years wether legal methods could be substituted by contracts under private law. Either public agencies or private institutions which profiteer from social servicies of forests, could sign a contract with a forest owner and agree on certain management activities and a price for them. The opinion seems to grow that voluntary contracts would be preferable to official orders. Still the possibility to order or forbid activities under certain and legally excactly defined circumstances is an accepted necessity.

It is accepted widely as well that under the given economic situation of forestry in Central Europe private and even corporative forest owners need public aid in the management of protection- or recration-forests. The rational behind that idea is the experience that the management of protection forests even without orders or bans is on account of the terrain-situation more difficult and costly than in forests which do`nt have to produce protection-services. The situation is similiar in recreation forests where the intensive use for recreational purposes forces higher management costs, especially for surveillance, damage-prevention and waste-disposal. Such public aid is not rated as a compensation but as a subsidy for management aggravations which are carried in the public interest as well. Such public aid can be and is given in widely differing ways. They can range from professional advice to monetary grants per area unit and year or to special regulations for the taxation of such forest land. Common practice is the subsidization of road construction as an essential to a careful forest-management, of precommercial thinnings or of other necessary management activities.

But even in private and corporative forests without a declaration to a special status can and is public aid used to foster the impelentation of management guidelines. The instruments of aid are similiar. They can reach from education and advanced training over different kinds of monetary incentives to tax-reliefs. The challenge for forest policy is not only to develop a coherent and well coordinated system of legal measures, compensations and types of public aid but to convince parliaments and governments to fund such a system sufficiently and reliable over a period of time.

Such sufficient funding is as well a prerequisite for the realization of a new management concept in public forests. Can it be achieved have public forest services the advantage of large areas and professional skill.

In Central Europe a new general concept of forestry and its management guidelines were developed and formulated over the last three decades. It seems to be widely accepted. It tries to combine ecological and economic as public and individual interests. Its implementation has begun with different intensity and success. Its continuation and completion over a long period of time will be an eminent challenge for forest policy in Central Europe.

LITERATURE USED

Odum, E.P.: Basic Ecology, CBS College Publishing, Philadelphia, 1983

Plochmann, R.: Impacts of Forestry on Forestry itself from an Economic and Socio-economic Point of View, XVII IUFRO World Congress, Japan, 1981, Interdivisional proceedings.

Plochmann, R.: Individual Objectives and Social Goals on Forest Resources, Proceedings Meeting IUFRO Division IV, Thessaloniki, Greece, 1985.

A SIMULATION MODEL OF ALLOWABLE CUT ESTIMATION

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FDC: 624.1--015.5

Yield regulation of forests with rotational cutting systems is based on age structure and stand volume. For the regulation of allowable cut, the indices of yield regulation are important. They characterize the data concerning the logging possibilities of forest stands. For the natural forest reproduction, the indices of cutting regulation have a decisive significance.

In Czechoslovakia, the cutting index for the management class is computed as the sum of products of individual volumes of age classes and corresponding cutting percentages which are tabulated according to duration of regeneration period:

$$I_c = V_i \quad c_i\% \quad 100^{-1}$$

where I_c = cutting index
V_i = volume of age classes within the regeneration period
$c_i\%$ = cutting percentage of a corresponding age class.

This method is aimed at maximum utilization of mature forest stands. To assure sustained yield and adequate cutting regulation, the cutting indices are balanced, and the allowable cut is estimated for three subsequent decades.

The development of the age structure can be expressed as a stochastic process using Markov's chain characterized by a transition matrix. According to this method, each decade's allowable cut per 1 ha ($E^{/t/}$) can be computed as the product of the vector determining the proportion of the cutting area in the age classes and the vector of volumes in individual age classes according to the following formula:

$$E^{/t/} = p^{/0/} \quad P^{t-1} \; V_{d8} \; pT \quad /1/$$

The result of this solution is the simulation model of the cutting intensity in the age classes according to probability theory, so as to reach the stationary vector "a" representing a normal proportion of age classes in the shortest possible time.

THE POLITICAL ECONOMY OF TIMBER PRODUCTION ON THE NATIONAL FORESTS OF THE UNITED STATES

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FDC: 903: 651: (73)

Political pressures to increase the economic efficiency of timber management and production on the National Forests have been increasing for about 30 years. Traditional arguments that uneconomic timber programs are in the national interest because they are used to improve wildlife habitat or the future health and productivity of forests or to support rural employment have lost credibility and acceptability. There is a growing belief both outside and within the Forest Service that current levels of timber production, and most particularly uneconomic timber production, should be reduced. It is argued that eliminating uneconomic timber management programs will both save money and reduce environmental degradation. Fewer taxpayer dollars would be wasted in the form of unwarranted subsidies to the wood products industry and larger areas of increasingly scarce natural conditions would be preserved for more important uses. In response to such concerns, for each National Forest, planning documents now must examine the economic dimensions of alternative timber management programs in great detail and an annual accounting of the expenditures and receipts of timber management must be made public. This paper traces the political and technical evolution of this focus on economic efficiency and summarizes the current situation.

SINGULAR OPTIMAL CONTROL APPLIED TO JOINT PRODUCTION OF RENEWABLE RESOURCES

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FDC: 641--01

The economic theory of joint production is formulated in the context of a renewable optimal control model. Generalized necessary conditions for optimal solutions are derived and compared for the static and dynamic joint production case. The generalized dynamic joint production solution is found using the linear variational approach. The procedure is applied to joint production data involving ponderosa pine and forage. Numerical solution to the optimal (maximum present net value) dynamic timber-forage production scheme is derived through an ad hoc numerical analysis technique. The optimal control results are compared to the solution for the same problem using a dynamic programming algorithm.

EVALUATING FORESTRY LAND DURING INFLATIONARY TIMES

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FDC: 652: (680)

The persistent double-digit inflation in the RSA since 1974 leaves no doubt that the country finds itself in a serious inflationary period. High inflation can be regarded as an almost inevitable fact of economic life which cannot be ignored in financial analyses.

The traditional Faustmann formula (LEV criterion), which has been used since 1849 to evaluate land for forestry purposes, does not take account of inflation and of the fact that individual prices do not necessarily follow the trend of general inflation. Theoretically, it is possible for each price within the cash flow of a forestry project to change at a rate which differs from that of a general price index. These individual price changes should also be considered in financial analyses.

The purpose of this paper is to present an adjusted form of the Faustmann formula which takes account of the changes in the dynamic financial environment of today. A worked example to compare the results obtained with the traditional Faustmann formula and the adjusted version is given.

A STUDY FOR MANAGEMENT AND YIELD REGULATION OF UNEVEN-AGED FORESTS

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FDC: 624.1: 228.6--015.5

Through the study of uneven-aged forest stands the past six years, an optimal management decision and an optimal yield regulation decision for uneven-aged forest stands can be formulated as a mathematical programming problem and a problem of dynamic optimization. In this paper, we collected much material on the growth, site quality, production cost, and return on investment of uneven-aged forest management. This paper is divided into three parts.

In the first part, a group of mathematical programming models which can maximize the total yield, or present net worth (PNW) or net return or multiple objectives of period in turn, were developed on the basis of dynamic models of uneven-aged forest growth for determining the optimal values of (1) growing stock, (2) diameter distribution, and (3) length of cutting cycle of uneven-aged forest management.

In the second part, a group of dynamic optimization models was developed on the yield regulation of various initial states of uneven-aged stands. The shortest time and greatest-in-benefit cutting path from current states to optimal states can be determined in these models by extending the regulation period.

In the third part, all of the models were examined using softwood-fir (Abies nephrolepis) stands of northeastern forest region and northwestern forest region of China, demonstrating that these models and software are of considerable worth to the forest manager in harvest decision-making and in forecasting timber output.

POTENTIAL OF FARM FORESTRY AS LAND USE TECHNOLOGY FOR RURAL POOR IN CENTRAL INDIA

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FDC: 913: (540)

The rural poor in central India are persistently dependent on available land for their food, fuelwood and fodder needs. The existing pattern of land use and basic needs of rural poor in central India is examined based on the field data. The production data for 50 farmers practising Farm Forestry in 10 villages in central India is examined in the present text. It has been observed that poor farmers owning about 2 to 3 hectares of land acre able to meet 60 to 70% of their basic needs, the extent of fulfillment of basic needs, the output generated per man-day and the Benefit Cost Ratios have been analysed for various Farm Forestry systems.

The following important observations are made: (1) By adopting Farm Forestry a farmer having two hectare dryland practising monocluture of field crops. (2) By adopting Farm Forestry practices a farmer having two hectare dryland improved the BCR by 65%. The results showed that Farm Forestry has immense potential as land use technology for rural poor, since, the other systems of land use have failed miserably in achieving desirable objective of sustainable production. Especially the resource poor farmers can achieve sustainable self-sufficiency by practising farm forestry in their small land holdings.

A FORESTRY MANAGEMENT MODEL:
THE RECENT EXPERIENCE IN SAO PAULO (BRAZIL)

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FDC: 903: 914: 907: 945: (81)

SUMMARY

The need to inplement an integrated policy to preserve natural resources, especially forest resources is increasingly urgent in the State of Sao Paulo. The deforestation rate of 200.000 ha/year in the last 5 decades caused seriousdesertification problems in 3 to 4 million hectares and a reduced capacity to supply drinking water to cities, among other imbalances. This paper showshowthe interaction between government, private enterprise and social entities seems to be the only alternative to reverse this scenario within the proposal of an all-encompassing forestry policy and how to suit the administrative structure to such proposal. The internal experience by the state organisms can today be disseminated throughout society as a whole and basically relies on the fact that it is possible to produce while preserving the environment.

Key words: conservation, forestry policy, ecoturism and fostering.

INTRODUCTION

The diagnosis of the current situation of natural resources (NR) in the State of Sao Paulo and especially forest resources unveils the urgent need to reverse the existing exploitation process. Only after deforesting, mostly in an irrational way, more than 80 percent of the state's territory did people begin to become aware of the consequences of such short-term production activities. The development of modern concepts and even revolutionary practices showed the need to reverse this soil occupancy model, as well as the need to suit the administrative structures, whether public or private,to attain such modifications.

This paper intends to show how we evolved from diagnosis to the action plan, including the pilot action by an organism dedicated to coordinating such task of changing concepts, expectations, attitudes and especially effective work, thus beginning to act on a statewide scale.

CONCEPTS (SOME THEORETICAL POINTS)

The basic concept of the whole policy of forest development in the State of Sao Paulo is that of preserving the natural resources as stated by the International Union of Conservation of Nature (IUCN), with the sole addition of the lithosphere resources. Thus, conservation of the NR means: "The of the utilization of biosphere (and lithosphere) by human beings, so as to produce the greatest sustained benefit for present generations, but which its potential to reet the needs and aspirations of future generations. Therefore, conservation encompasses preservation, maintenance, sustatined utilization,restoration and improvement of the natural environment. The conservation of living resources is specifically related to plants, animals and microorganisms,as well as to the inanimate foods in the environment which they depend upon", which leads us to three basic lines of action: CONSERVATION, SUSTAINED UTILIZATION and ENVIRONMENTAL EDUCATION, which can be further summarized as "Protecting and preserving to know it better. To know it better in order to produce in a self-sustained way yo meet current and future social demands". This is the triple foundation which guided the creation of an organism earmarked for coordinating and implementing a comprehensive policy of forest development in our state.

Diagnosis of Forest Situation in Sao Paulo

In order to know the magnitude of the forestry issue in the State of Sao Paulo, it is worthwhile making a brief diagnosis both in terms of the evolution of deforested area in the state and of the existing institutional structure inthe sector and its operation.

Physical and economic characterization of the state

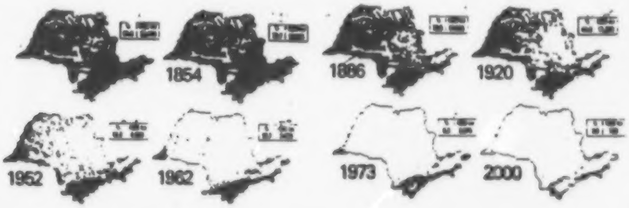
The State of Sao Paulo is one of 24 Brazilian States, with its own Executive, Legislative and Judiciary branches. It has 572 municipalities and is divided into 11 Administrative Regions. Its average per capita income is roughly U$$ 7.000/year. It is the largest industrial producer in the country andthe second in agricultural production. It has about thirty (30) million inhabitants, 85 percent of whom live in urban areas. It is located betweenparallels 20'and 25'south latitude and 44'to 53' west longitude, withprevailing sub-tropical and wet tropical climates, average temperature ranging between 18' and 26' (65'and 79'F) and 1.000 to 2.000 mm/year rainfall.

The deforestation process in the State of Sao Paulo

SERRA et al. showed in an irrefutable way and with brutal realism the process of destruction of the native vegetation in the state. In a time span of three generations, approximately 80 percent of the forests in the State of Sao Paulo were destroyed, purportedly to expand the agricultural frontier and basic infrastructure. The mere observation of the sequence shown below demonstrates what the state was transformed into, deforested at a rate of 200.000 ha/year (FIGURE 1).

Desertification today plagues around 4 million hectares. The metropolitan region of the capital city of Sao Paulo will already have drinking supply problems by the year 2000. Medium-sized cities in the interior of the state are beginning to feel the pinch of water supply problems due to destruction of watersheds. The largest industrial chemical complex in the country (Cubatao), as well as its largest seaport (Santos), are under risk of being buried by landslides from neighboring slopes. The large hydroelectric plants have their working life reduced by one third due to silting up of their reservoirs. This is the scenario demanding urgent action, which necessarily goes through the adoption of a comprehensive forest policy.

Figure 1. Reconstitution of Forest Coverage in the State of Sao Paulo



SOURCE: CAVALLI, SERRA and GUILLAUMON in VICTOR, M.A., 1975

Official policy for the forest sector - institutional organization

More than one hundred years ago (1886), the first state entity concerned with issues related to the physical envirornment was created in the state: the Geographical and Geological Commission, which gave rise to the main official organisms that operate in the area of natural resources: Geological Institute, Geographical and Cartographical Institute, Botany Institute, Forestry Institute and Paulista Museum, just to mention the major ones. In the forestry area proper, the Forestry Institute is responsible for research and technological and is also the entity in charge of managing the Parks and other conservation units in the state, besides having a reasonable timber-producing potential, since it devoted itself to extensive planting of rapid-growth forests in the past. The inspection policy is carried out by DEPRN - State Department of Natural Resources Protection, together with the Forest and Watershed Police,bydelegation from IBAMA - Brazilian Institute of Environment and Natural Resources. This structure, however, does not ensure the coordination of a forest policy at the state level, nor was it capable, in turn, to check the deforestation which took place in this century. The organisms in charge of the forest issue report to the State Environ*ment Department, which also counts on a new organization, the Foundation for Conservation and Forestry Production in theState of Sao Paulo, founded on the modern conservation concept, and which hasbeen coordinating the state's forest policy, first only internally and based onits own experience, and then extending its action on a statewide basis.

Institutional Proposal - State Forestry Foundation

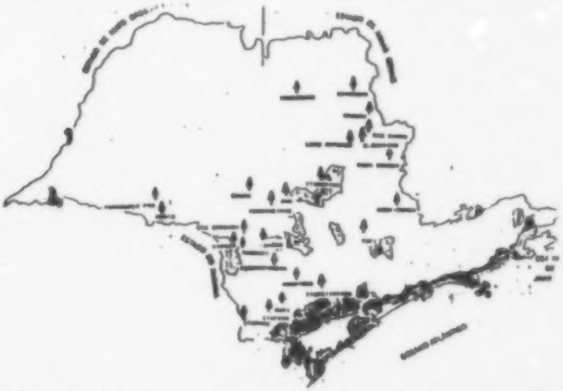
This institution has carried out a consistent plan which brings together production/conservation and education. It also intends to stress that these three aspects are not conflicting ones, but rather superimposing and complementary, allowing for a harmonic development process. A pioneering experience in the State of Sao Paulo took place between the Forestry Institute - I.F.(centralized administration) and the Foundation for

Conservation and Forestry Production in the State of Sao Paulo - F.F. (decentralized administration), thus enabling us, after the initial adjustments, to extend the development proposal based on the conservation concept to the state as a whole.

THE EXPERIENCE IN STATE-OWNED AREAS

At a first stage, the action by F.F. was aimed at the forest areas under I.F. control. In terms of native vegetation, this area is made up of the vast network of Reservations and Parks, which encompass today the last remnants of the state's indigenous flora, totalling about 800.000 hectares, besides 27.000 ha of forests planted with exotic plants.

Figure 2. Forest Areas under control of the Forestry Institute



SOURCE: SMA

The objective of the joint action by F.F. and I.F., in the production area, is to streamline and maximize the exploitation of commercial forests, concentrating resources in the areas of conservation of Parks and Reservations, research and production itself. F.F. plays an eminently managerial role in this process.

This work aims at stimulating: a) planting of homogeneous or heterogeneous forests for economic and/or protectionist utilization and the generation of technology to utilize the wood planted to substitute for the wood extracted from native forests. It also develcps a methodology to make the sustained exploitation of the forests as well as the economic utilization of the Conservation Units a feasible task.

This action takes place at various locations in the state, allowing us to have an adequate knowledge of the ecological and socioeconomic conditions of the various regions.

In order to have a better understanding of the actions undertaken and the results already obtained, it is worth while dividing our explanation below into production and conservation aspects.

Actions in the Production Area

Area of action and current situation

I.F.'s afforested area encompasses nearly 27.000 hectares of total exploitable area. This area was planted mostly with various species of Pinus, especially in the 1959-1965 period. This area is not continuous, but scattered throughout the state.

These plantings presented a series of problems, such as inadequacy of species introduced, poor maintenance (firebreaks, roads, ant control, trimming, etc.), besides delayerd thinning.

Production and selling of both wood and resin, besides new plantings, were made by the Institute on an as-needed basis, without any commercial or silvicultural planning.

Method utilized

A strategic planning was prepared to organize production, encompassing the development of long-term programs (30 years) which adopted the following assumptions:

1. 30-year cycles, with five thinnings and final cutting.
2. 80 percent of plantings with Pinus and 20 percent with Eucalyptus spp.
3. Adaptation of the species (tropical and temperate climate plants) according to their ecological requirements.
4. Cultivation of Eucalyptus species aiming to meet forestry and industrial demands.
5. Maintenance of control plots for further research purposes.

Starting from this plan, various programs were prepared to make the exploitation of such resources more rational. The introduction of forest management methods was fundamental for attaining short-term results, as in the case of the F.F./I.F. cooperation (2 years). The main subprograms in the area of production are listed below:

- Production Forest - raw wood and resin production
- Production of Seedlings - exotic and ornamental/native seedlings
- Production of Seeds - pinus, eucalyptus, native and others
- Technology of Forest Products and Byproducts: sawed timber, logs and housing modules of treated wood.

These subprograms form the Self-Sustained Exploitation Program for Production Forests, Whose results are shown below.

Self-Sustained Exploitation Program for Production Forests

The existing difficulties for the management of planted areas and production of seedlings and seeds begin to be overcome by F.F.'s action in selling delayed thinnings and the deep cutting of areas with species to be replaced (low yield locations).

Thus, raw timber production was increased to over 500.000 cubic meters a year and new plantings attained levels quite superior to those obtained by I.F in the last few years and shall continue as such, in accordance with the longterm strategic plan (see Graphs I and II). Yield will also be increased due to the introduction of new species (see Graph III).

The other products such as resin, seedlings and seeds of exotic species will also have their production optimized and their commercialization carried out on a technical basis.

Due to the strategic importance of the techology to utilize forest products and byproducts, a subprogram was developed to deal specifically with this issue.

Forest products and byproducts technology

F.F. has been managing three industrial units for the mechanical processing and chemical treatment of wood, namely: the Itapetining Unit, producing sawed wood from pinus; the Manduri Unit, producing sawed wood from pinus and wooden houses from treated pinus, and the Luiz Antonio Unit, producing eucalyptus logs for fence posts, struts, railway sleepers and light poles.

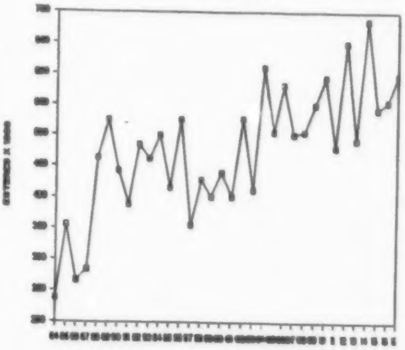
TABLE 1. Planting and production evolution
I.F
at I.F. areas

ITEM	PLANTING (hectares)	PRODUCTION (1,000 m^3)
84-87 Average (I)	270	280
88 Actual (II)	901	460
% Increase (I/II)	233	64
89 Actual (III)	970	525
% Increase (II/I)	260	87
Next Years' Average (IV)	1000	550
% Increase	270	96

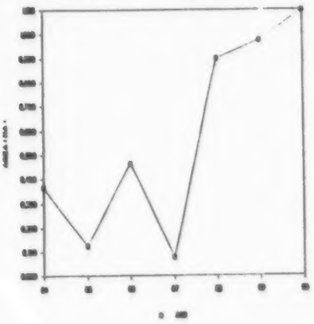
SOURCE: I.F. and F.F.

GRAPH I - WOOD PRODUCTION -

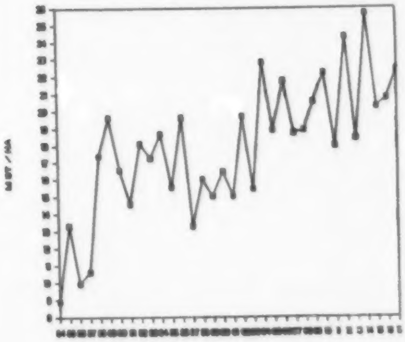
STATION



GRAPH II
PLANTING AT I.F. EXPERIMENTAL STATIONS



GRAPH
AVERAGE PRODUCTION INCREASE AT



SOURCE: I.F. and F.F.

In order to commission the units to their present operating status, a total of U$$ 147.743 was invested; the results of less than one year of operation are summarized in the table below.

TABLE II. Situation of I.F. Industrial Units

UNIT	CAPACITY	PREVIOUS SITUATION	CURRENT SITUATION (Production)
Itapetininga	1,700 m^3/month	Shut down	200 m3/month
Manduri	200 m^3/month	30 m^3/month	200 m3/month
Luiz Antonio	1,000 m^3/month	Being refurbished	Start-up

SOURCE: F.F.

The main products already being developed by the F.F./I.F. cooperation are housing modules made of treated pinus woods. This product is aimed to create alternatives both for the housing problem and for the installation of public use social equipment. In this regard, more than thirty (30) Forest Police station ofis have been installed throughout the state.

Actions in the Area of Conservation

Conservation Areas under Forestry Foundation management

F.F. is directly responsible for the management of 68.300 hectares of preserved areas, encompassing three (3) conservation units (CUs) among the most significant ones in the State of Sao Paulo, besides providing managerial support to six (6) other units managed by I.F.

Intervales Farm (FI) - Area of action and current situation

Located in the southern part of the state, with an area of 38.000

hectares of Atlantic Forest on a rough terrain, ranging from 70 to 1.000 m above sea level. On the mountain region, the high ridge tops define the water divider which feeds two large river basins. The Farm is the point where three other CUs meet, totalling 120.000 hectares of continuous, preserved woodlands which boast a large quantity of wildlife and plalnt species. FI was previously managed by a company which carried out mining operations and commercially extracted heart -of-palm in the region. It had about 70 employees, poorly-maintained equipment and vehicles, facilities nude up of headquarters, living quarters, plantpffice, warehouse, repair shop and others. Since roughly all the area was preserved, the Farm was put under F.F.'s responsibility.

Results obtained

In 20 months of management, it was able to change the existing situation, whether by restructuring the staff, putting up teams to serve visitors, guards, guides, monitors and general services, with training and guidance towards conservation activities, from an integrated forest management point of view. The objectives defined aimed at establishing effective ways of conservationist actions through 2 basic subprograms:

Environmental Education and Ecotourism: To serve the scientificcommunity, students and public in general aiming at developing and/or enhancing concepts and habits which favor the preservation and/or conservation of the environment through courses, symposiums, debates, lectures and other oriented educational and recreational activities. Ecotourism aims at providing the visitors with contact and life in various natural environments, following monitored or selfguided trails which include, among other attractions, caves and waterfalls. This subprogram is also the main source of funds for maintaining the Farm, which has an Administrative Center, Reception Center, Lodging, Cafeteria, Hall, Cafeteria, Hall, Handicraft and Leisure Equipment.

Research and Management: Ensures the supply of infrastructure and to scientific research and activities involving researchers from various areas of knowledge aiming at investigating the rational exploitation of alternative products, the Environmental Education and Ecoturism work, and expanding the knowledge about the Atlantic Forest. Currently being developed are: Speleological Assessment; Assessment of Mammalian Wildlife; Birds Assessment and Ecology; Studies on the Waterborne Macro-Invertebrates; Study on the Potential Use of Natural Resources at Inter-vales Farm, and a Pilot Project for Production of Edible Fungi.

Cardoso Island State Park - Area of action and current situation

Located on the southern coast of the State of Sao Paulo, 25010 south latitude and 480 west longitude. Its total area is 22.500 hectares and it is located in an estuary-lagoon region, which makes it a large natural breeding place. It is considered by IUCN as the third in the world in terms of primary productivity. The Island is quite mountainous, its highest peak reaching 900m above sea level, and is covered with typical Atlantic Forest vegetation. In its southern portion, the terrain is smoother, giving rise to a long sand stretch ("restinga"); the west side has plenty of beaches and rocky locations, whereas marshes prevail in its internal sea. The Park was created in 1962 but, due to the lack of official land ordinances, around 350 people currently live on the Island, distributed in small population clusters along the coast. In 1972, CEPARNIC (Center for Applied Research of

Natural Resources at Cardoso Island) was created, with a large physical infrastructure made up of administration facilities, laboratories, living quartes and houses for technicians and employers, which had been half abandoned for lack of funds.

Results attained

Starting June 1988, F.F. undertook the Park's administration and for the last 18 months has been investing to restore and improve the building sand equipment by guaranteeing and encouraging research activities. It also transformed part of the facilities into an Administrative Center and Education and Ecotourism Nucleus as a support for the Park's activities, whose main aspects currently are: Environmental Education and Ecotourism - of courses for elementary and high school students lasting 3 days each, with field work at the existing ecosystems (marshes, woodlands, sand stretch, coast and beach); training for public school teachers; service to visitors and work with the local community. Research and diffusion of technology - Models for land use planning and Conservation Ecology of Cardoso Island; analysis of vegetation; assessment of vertebrates; assessment of forest products from endangered species; oyster farms; inspection and conservation of fish.

Cantareira State Park - Operation area and current situation

It is a Reservation area which was turned into a Park and is atits initial stage of implementation. It possesses 7.880 hectares with a perimeter 130 kilometers long, located in the region of the city of Sao Paulo ina watershed protection area. It is a new experiment, since it is largely surrounded by urban concentrations in one of the largest cities in the world lacking green areas. For this reason, its implementation has been on a step-by-step basis in order to allow for greater control and assessment of impacts.

Results Attained

Review of the Management Plan; basic research; Fire Protection and Fighting program; Public Awareness program; implementation of the Administrative Center; implementation of the Pedra Grande Nucleus (first nucleus for Public Use and Environmental Education).

F.F. action in this conservation area, as seen above, has tried to demonstrate the feasibility of using CUs as a social apparatus, even part of the funds necessary for its own maintenance. The methodology developed throughout these months of activities already allows us to extend some actions to other CUs run by I.F., thus trying to enhance this field.

TABLE III. Results Attained at Conservation Areas

AREAS	INVESTMENTS US$	REVENUES US$	# OF VISITORS
Intervales Farm	142,000	44,000	7,100
Cardoso Island State Park	86,000	42,000	6,500
Cantareira State Park	540,000	-	-

SOURCE: F.F.

OPERATION IN EXTERNAL AREAS

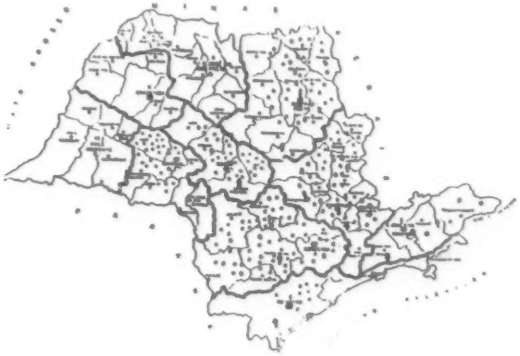
The joint action with other state agencies and private entities was made possible through the Forestry Fostering Program. The proposal was "to a partnership between government, private enterprise and social entities aiming at developing a forest development program defined upon mutual agreement", which could be extended to other sectores.

The Fostering aims at "making forest exploitation a feasible commercial option for using lands unsuitable for agriculture and cattle raising (calculated around 3.0 million hectares), besides contributing to reclaim degraded areas, thus relieving the pressure on native reservation areas, which will result in a greater environmental balance". After a period of discussions and the following entities joined the Program:

- Sao Paulo State Paper and Pulp Manufacturers Association and Sao Paulo State Afforestation Association - by donating seedlings of encalyptus produced at their associates nurseries (see map).
- Agriculture Houses - agencies of the State Government linked to the Agriculture Department, with agronomists spread throughout the state, being responsible for providing the Program with technical assistance, enrolling producers and following up the implementation and development of
- Forestry Institute and State Department of Natural Resources Protection, both organisms from the Environment Department - by giving technical support through training courses to the Agriculture House technicians.
- Forestry Foundation - coordination of the activities, from the follow-up and enrollment of producers to the final control of planting.

In two months of operation, 1.6 million seedlings had already been requested to nearly 300 producers all over the state (see map), whereas the initial schedule foresaw 1.2 million in six months, to be distributed the state. (FIGURE 3).

FIGURE 3. Operation areas of the State Program for Forestry Fostering



SOURCE: F.F./SAA/ABPPC

GENERAL EVALUATION AND PROSPECTS

From the above, we were able to observe how the application of a new concept, through an entity created specially to put it into practice, managed in a short time to substantially alter forest management in the official sphere of the State of Sao Paulo.

Such actions enabled the formation of a critical mass of knowledge which allows us to extend this administrative methodology to other social sectors, aiming at implementing a global forest policy for the state, specified by a forestry development plan.

Thus, some assumptions were made in order to make this plan feasible:
- the existence of a coordinating organism with decision power;
- conservationist activities "strictu sensu" must generate funds and be the object of investments;
- neither the state government, nor private enterprise and social entities can, isolatedly, carry out statewide programs;
- establishment of a new partnership between government/companies/social organizations to implement the plan.

Based on these points, the following objectives and goals were set:
- to curtail the *desertification process in the State of Sao Paulo (by the year 2000, three to four million *hectares are predicted to have become deserts);
- to start a process of regeneration of trees in the State of Sao Paulo in order to attain a lasting balance, according to the standards set by international organizations;
- to maintain this balance along time through the development of production techniques which are not aggressive to the environment;
- to promote, maintain and develop an environmental awareness in the population.

For this purpose, it will be initially necessary to afforest 4 million hectares in the next 25 years. From this total, 1 million hectares will be earmarked for protection woodlands aiming at: preserving watersheds, riparian woodlands, stabilizing slopes; protecting wildlife, flora and other genetic resources; fostering recreation, environmental education and ecotourism; recovering riparian woodlands and degraded areas. In this group, some specific programs stant out, such as "tree planting at roadsides", and "rapid growth forests", aiming at controlling the emission of CO2 into the atmosphere.

The other branch of the plan proposes the planting of 3 million hectares of production forests (eucalyptus, pinus and other species) designed to meet the industrial needs for raw materials for pulp, mechanical processing and energy generation, thus trying to attenuate the effects of the expected timber deficit and minimize the pressures on the re*maining reserves of natural woodlands.

The plan as a whole aims at planting 300 million trees or 160 000 hectares a year, for 25 years, at a cost of 160 million dollars/year, or 4 billion dollars (in 25 years).

Besides the notorious environmental upgrading this activity will entail, also evident are its socioeconomic benefits, especially by the creation of jobs and taxes.

CONCLUSIONS

This paper tried to demonstrate the feasibility of implementing a statewide policy of integrated forest development in the State of Sao Paulo, by means of: 1) the adoption of a modern, comprehensive concept; 2) the existence of suitable administrative structures; 3) the experience of at least 2 years with organizations in the public forestry sector; 4) the preliminary results obtained with production, conservation and especially forestry fostering programs; 5) the willingness to undertake the implementation of this global policy through a common collaboration effort between the state government, private companies and social organizations; and 6) the ecological, economic and social feasibility of the program, which extends along a relatively long period of time and at effectively compatible costs.

BIBLIOGRAPHY UTILIZED

Castanho Fo, E.P. et al. 1984: Fundacao para a Consercao e a Producao Florestal do Estado de Sao Paulo, Coordenadoria da Pesquisa de Recursos Naturais. Secretaria de Agricultura e Abastecimento do Estado de Sao Paulo.

Castanho Fo, E.P. & Feijo, L.F.C.A. 1986: Politica Setorial de Recursos Naturais para o Estado de Sao Paulo - Contribuicao a Estrategia Mundial para a Conservacaor, Coordenadoria da Pesquisa de Recursos Naturais, Secretaria de Agricultura e Abastecimento do Estado de Sao Paulo.

Castanho Fo, E.P. 1988: Politica Florestal do Estado de Sao Paulo, Fundagdo para a Conservacao e a Producao Florestal do Estado de Sao Paulo, Secretaria Estadual do Meio Ambiente, Sao Paulo.

Conselho Estadual do Meio Ambiente. 1985: Areas Naturais do Estado de Sao Paulo, Governo do Estado de Sao Paulo, S.Paulo.

Fundacao Florestal. 1988: Plano de Acao 88/89 - 89/90 - Preliminary Version, Sao Paulo.

Instituto Florestal. 1984: Programa de Reflorestamento em Terras PUblicas. Coor denadoria da Pesquisa de Recursos Naturais, Secretaria de Agricultura do Estado de Sao Paulo.

Secretaria do Meio Ambiente 1988: Politica Estadual do Meio Ambiente, published by SMA, Sao Paulo.

Sociedade Brasileira de Silvicultura. 1987: A ConservaCAo da Natureza e o Patrimonio Florestal Brasileiro, S.Paulo.

Unido Internacional para a Conservacao da Natureza e dos Recursos Naturais (IUCN). 1985: Estrategia Mundial para a Conservacao - IUCN, collaboration FAO(UN), UNESCO, UNEP and WWF, published by Companhia Energetica de Sao Paulo.

Victor, M.A.M. 1975: A Devastacao Florestal. Sociedade Brasileira de Silvicultura, Sao Paulo.

SOCIO-ECONOMIC ASPECTS IN FOREST MANAGEMENT IN INDONESIA

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FDC: 901: 62: (910)

Vast tracks of forest resource are found on different islands in Indonesia. They vary in extent, type, and condition. In addition,the population inhabiting areas within and around the forest have various ethnic backgrounds. Consequently, in order to be able to properly manage these different types of forest in different locations, social and economic factors need to be taken into account.

Factors found to be important in contributing to the proper management of the different types of forest on different islands are the cultural background of the ethnic group, the density of the population, the stage of development, and the accessibility of the forest.

Difference in strenghth of influence of social econmomic factors are noted on the management of forests in different regions, i.e.,in South Sumatra, East Kalimantan, and in Yamdena island of Southeast Moluccas. Social factors play more important role in the management of less accessible forest . In the more-accessible forest, on the other hand, economic factors are more influential.

PLANNING AND MANAGEMENT OF VILLAGE FORESTRY IN TANZANIA: A SYNTHESIS OF EXPERIENCE

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Tanzanian forest resources cover 44.4 million ha (43% of total land). Main wood product is woodfuel with annual consumption of 22 million m^3 constituting 91% of the macroenergy consumption. Woodfuel acquisition, overgrazing, wild fires and agricultural development have triggered annual national deforestation of 300,000 to 400,000ha. Frontal development to deforestation is village forestry.

Since village forestry was initiated in 1967/68, the achievement has been marginal compelling the re-examination of the methodology. In the past, partial or nonadoption on village forestry technologies has been viewed in terms of villagers' characteristics and those of the forest extensionists but not in terms of the characteristics of the innovations themselves. Synthesis on village forestry in Tanzania indicates a need to adopt "participatory technology development" (PTD) whereby village phases of rural development programmes. The overlooked characteristics of the innovations in village forestry developed by forest scientists unilaterally may explain programmes to date in Tanzania.

Limited research done along PTD locus has concentrated on situation analysis, identifying problems, setting proiorities, and choosing promising solutions on village forestry for investigation or testing in a form of village case studies. Implementation and monitoring of the planned village forestry programmes have yet to be conducted.

Keywords: Village forestry, participatory technology development, planning.

IMPACTS OF AGRICULTURAL AND FOREST POLICIES ON WATERSHED MANAGEMENT: A CASE STUDY FROM COSTA RICA

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FDC: 913/914: 116: (728.6)

SUMMARY

The Nosara watershed in Costa Rica provides an example of an area where the effects of different types of policies have been followed.

First the agriculture and livestock policies of the country created the conditions for the inmigration of people from other parts of the country. So long as the conditions for the farmers (incentives and prices) where good enough, a deforestation process occurred, accompanied by diminishing soil fertility and soil erosion.

With the problems in the livestock markets, the situation for the farms worsened. Also, the supply of water fell to a critical level. New changes in land use occurred replacing cattle farming by coffee crops.

In the most affected areas a reforestation program was started, supported by a research project and by a reforestation incentives policy. Afterwards, the reforestation movement with small farmers, initiated in Nosara expanded to the rest of the country.

The impacts of different policies over time are analyzed; and a methodological framework is derived for analysis of similar cases in research programs.

FORESTRY FOR RURAL DEVELOPMENT:
THE ISSUE OF INCENTIVES IN UGANDA

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SUMMARY

Incentives to the private sector are one new avenue to increase forest management plantation and afforestation in Africa. Land tenure, extension activities, financial incentives, subsidized loans and the right market price for timber are discussed here as means to improve private forestry initiatives in Uganda.

Keywords: Incentives, forestry development, private sector.

INTRODUCTION

This paper discusses the type of incentives that could be offered to Ugandan farmers in order for them to get involved in forestry production. Forestry production has been identified as one of the activities that can help to bring about rural development, more so if the rural people themselves are engaged in it. Before the discussion on incentives is presented, background information on the country's potential for development in light of the prevailing conditions is given, outlining the importance of soil types, characteristics and fertility in agricultural production. Soils are also discussed in relation to forest cover, and the issue of forestry as land use is also discussed indicating the role trees play in Uganda's economy, both directly and indirectly by modifying the climate, protecting water supplies and preventing excessive soil erosion.

The discussion on incentives start by examining the policy issues. A change in forest policy statement is necessary because under the present one, people's needs and demands are not well covered. The incentives discussed here include:

Extension service, which has been identified as very important service in farm forestry.

Economic incentives like loan schemes, rewards and compensations and markets.

BACKGROUND INFORMATION

Uganda is an agricultural country, but now and then Ugandans are reminded of the great potentials for industrial development by the leaders of the day. However, given the extent of capital requirements, and the technical knowhow needed for industrial development, agriculture and forestry will continue to play major roles in Uganda's economy. It is, therefore of considerable concern that the country's tree resources are being rapidly depleted, leading to an increasing shortage of forest products such as firewood, sawn timber, etc., as well as general environmental degradation. Just like elsewhere forests in Uganda serve a number of protective roles, helping to maintain soil fertility, prevent soil erosion, provide a reliable water supply, etc., a service which is very important to the country's agricultural development. Yet to a number of Ugandans, it is of less importance not because they do not want to maintain soil fertility of their shambas (gardens) or to prevent soil erosion of the same or to have a reliable water supply, but because they are very poor, and see no immediate direct monetary benefits attached to such a service. To them, tree resources are only important when people are able to get direct monetary benefits from them. As the protective service of forests has been overlooked, the productive capacity of land to produce food and other agricultural crops has declined. Thus more forested area has been cleared in order to produce food and case crops to feed and earn some cash for the ever increasing population.

Soils

The Characteristics of soils exert major influences on vegetation and land use in Uganda. Soil properties are determined by a number of factors including: climate, parent material, topography, plant and animal influences and land use; and soil variation occurs on several quite different geographical scales. On the smallest scale, there can often be striking variation related to factors like the farmers' positions of house sites, anthills, animal compounds, bonfires and tree stumps (Eggeling 1948a: Chenery 1960). On the intermediate scale there is major variation associated with topography, soils of hilltops tending to differ from those of mid slopes and both of these contrasting markedly with those of valley bottoms. On the largest scale, there is a tendency for particular soil types to be associated with major climatic zones. This is evident in the very wide distribution of ferralitic and, to a lesser degree, ferruginous soils, each is developed on a variety of parent rock.

According to the Atlas of Uganda, the ferralitic soil is the most widely distributed type, occurring in both forest and savanna zones. Its profile consists of a thin (20-35 cm) topsoil and a deep (often over 5m to even 10m) subsoil. Organic matter and nutrients are strongly concentrated in the topsoil. The subsoil consists mainly of kaolinite clay and iron oxides and contains few reserves of weatherable minerals. Ferralitic soils can be productive, a characteristic attributable to the relatively high rainfall, considerable soil depth and relatively nutrient-rich topsoil. It is vital to realize that soil fertility can be easily and rapidly diminished through erosion of the topsoil, and that once lost, it is prohibitively expensive to restore. The input of plant nutrients into the soil body either through rack weathering or by arrival in rain or dust from the atmosphere, proceeds at a rate which is much slower than that at which nutrients can be lost through bad management. Therefore one would be correct to regard in practical terms the soil cover of Uganda as an irreplaceable capital resource.

Forestry as a Major Form of Land Use

Forestry is one of the major forms of land use in Uganda. Forestry service was created in 1898 under the Department of Scientific and Forestry Research. The forestry department was established as a separate body in 1917, and was renamed the Forest Department in 1927. The process of acquiring land by the forest department was gradual and to a degree unsystematic and it was not until the 1940s that the boundaries of the forest estate became established.

A report, by Nicholson 1929, dealing with forestry was written and adopted by the Government. Nicholson stressed the fact that forests and trees play important roles in the environment, both in direct economic ways and indirectly by modifying the climate, protecting water supplies and preventing excessive soil erosion. He considered that supplies of firewood, poles and sawn timber for local consumption in the countryside could best be guaranteed by encouraging tree growing by farmers and by the establishment of small plantations under the control of local administrations. The role of the forest department was to safeguard the environment and forest resources on a long term basis. Many of Nicholson's suggestions regarding the aims of the forest department were incorporated in an official forest policy statement in 1948.

A significant change in the forest policy statement of 1948 compared with the forest policy advocated earlier by Nicholson was the down-grading of the value of protective forestry in recognition of the pressing immediate demands of agriculture, Hamilton, 1984, argues. "Because of Uganda's dependence on agriculture, the need for rapid development of the country, and the continuing increase of its population, it is necessary to limit the size of the forest estate to a minimum area which will achieve the primary aims of management," the forest policy states. Although there could have been no reliable method of determining the size of the minimum area in the meaning of the statement, nevertheless a "minimum area" was calculated for each administrative district. When the actual area of legally protected forest reached or exceeded this amount, then the district was declared to be adequately forested. Minimum areas were calculated using figures for wood consumption per head and the size of district population, and there was also an initial aim to place ten percent of the land area of Uganda under forest (Hamilton, 1984). Theoretically the minimum area would increase as either the wood consumption per head or size of district population increased. Practically, it has decreased as both parameters increased.

In 1938 and 1947, legislation establishing forest reserves under district (local) administration was enacted. These local forest reserves were small in size, numerous and scattered and were expected to satisfy the local demand for forest products. Their establishment was in line with the Central Government's postwar development plan, which laid particular emphasis on the provision of small area of natural forest or plantation to supply wood products to the rural community on a permanent basis (Forest department, 1955). For example, a scheme known as 'Buganda Dedication Scheme' was started in early 1950s, giving owners of private forests on "Mailo land," the chance to lease their forests to the then Buganda Government for a period of 99 years (Sangster 1951a & b). Leased forests were to be managed by the local forest service to give maximum sustainable timber production and the owner would receive 75 percent of the profits. However, this scheme failed, probably because of the highly emotive nature of land in Buganda. Another scheme tried out at this time and which also failed, was the establishment of communally owned village forests.

In 1967 the forest services run by district (local) administrations were absorbed into the centrally organized forest department. This amalgamation was not due in any direct sense to considerations of forestry or environmental welfare but was rather a part of the general shift towards political centralization which followed the abolition of the 1962 Constitution. After centralization, the forest department relinquished some of the small forests (up to about 20 ha.), on the grounds of economic inviability.

Incentives

Agricultural production in Uganda is through small holdings, and yet the country is now a net exporter of food items like maize, beans, soy beans, etc. This is so because there are incentives for the smallholders to engage themselves in such production. As far as forest is concerned almost all productivity is controlled by the government and yet even the local demand for various forest products is not met. The question I keep on asking myself is, "given incentives for production of forest produce, cannot the same smallholder engaged in agricultural production do the dame for forestry? In my opinion, supported by personal communication with a few smallholders, farmers in Uganda can successfully engage in forestry provided they are well motivated. This motivation can be done through offering incentives to them. And here I would like to suggest some of the incentives:

Policy issues

In order to offer effective incentives to farmers to bring about rural development through forestry, there must be a change in forest policy statement. Such a change is necessary because successive governments in the country, operating under the present forest policy, have failed to satisfy people's demands for forest products from government forests. The reasons are many and are not discussed here. Given the current level of environmental degradation, the country requires a policy framework which put more emphasis on protective forestry. Presently, the protective aspect of forestry is aimed at the traditionally unstable areas viz watershed, hillsides, etc., mainly on public land. Yet private and other public areas which are also suffering degradation should also be included in the protective aspects. As I indicated earlier a few Ugandans do appreciate the protective services of the forests in their country. This however, does not mean that the majority of Ugandans do not understand or know the dangers caused by deforestation. They do but, because of the poverty circle which entangles them, they would cut down trees even those in protected areas either for earning a few shillings or for home consumption, at times it is a matter of survival. So as the role of forests in protecting the environment is now more appreciated by the government than the public, I would urge the former to put most of its resources (money, manpower, etc.,) in protecting the environment.

The second major aspect of the forest policy statement is productivity. The supply from the existing productive forests fall short of the demand, hence the protective forests are now being cleared in order to supplement the supply from the productive forests.

This shortage in supply of forest products is expected because way back as early as the late 1950s it was forecasted that there would be a shortage of forest products from the then existing forest estate, unless Afforestation programmes were started to supplement the supplies from natural tropical forests. Although such programmes had started in early 1960's, due to political instability in the last two and a half decades they came to a standstill.

The productive aspect of forests is well understood by Ugandans, may be because of the monetary value attached to it. Therefore this must be identified as the area where farmers can be encouraged to participate in forestry at first. This will require identifying people's needs and demands for forest products in each administrative district. Then the government to draw up a policy, the forest extension officers will be used to help farmers set up and manage their own forests/woodlots. Because of the longevity of production process of forest enterprise as compared to production process of agriculture, a land use policy which ensures the use of land by tenants with minimum conflicts and guaranteeing tenants rights in land tenure should be adopted.

Extension service

The importance of farm or community forestry today in providing fuelwood for over ninety percent of the country's population presupposes the existence of a capable and efficient forest service. But at the moment forest extension service is not taken seriously even by the forest department itself. This, therefore, means that the extension worker is not availed the necessary assistance and authority to carry out his/her work.

The following observations have been made of this important service, that:

The Forest Extension Officer seems to have no specified duties or even job description because at his/her level of operation, all authority lies with the District Forest Officer.

The forest department, using the above, metes out its punishment to unruly staff by making them Extension Officers, thus making such a job more unpopular!

There is no provision for training Extension officers in say, mass communication and other fields that one must be conversant with in order to be an effective Extension Officer.

The following suggestions are therefore made:

There must be a provision in the forest policy to separate large scale afforestation undertaken by the government from community forestry so that the Extension Officer is assigned duties related to forestry at the local level.

Before the above can be done, however, it is necessary to establish a strong effective forest extension section in the department. This section should ideally be headed by an Assistant Forest Officer. officers under him/her should have proper job description and their activities should as much as possible form a link between the tree farmer or user and the research/policy makers at the department headquarters.

The present Extension Officers need some form of re-education so as to be able to address themselves to specific issues facing the Ugandan forest user today. Training in Agroforestry, short rotation forestry, mass communication techniques and other related disciplines should be made a pre-requisite for all intending Extension Officers and should ideally be provided by the forest department itself.

Economic incentives

Economic incentives can take a large number of forms, which could be either direct or indirect. This paper discussed loans and rewards as direct incentives in cash at community level, and marketing services as an indirect incentive.

Loans. The present Uganda rural credit schemes do not cover forestry development. They cover mainly agricultural production, commercial and industrial development. In order to bring about rural development which will taken environmental issues in account, forestry development ought to be included in the rural credit schemes. However, given the length of production process in forestry which is in most cases longer than those of agricultural and industrial production, farmers who are engaged in forest should be given loans on "soft terms." There are several cases where some farmers are incapable of handling cash and yet they would like to get loans for forestry production. In such cases the individual farmer could go in agreement with the government, under which the government agent could undertake cash management and management of woodlots on a private land, and then share the profit with the farmer at an agreed percentage. But in a situation where the public has little confidence in the government, the farmers are likely to be unwilling to enter into such a venture!

Rewards and compensation. Rewards can be offered to individual farmers whose efforts and achievements in practicing forestry has been outstanding in a given period, starting at village levels up to national level. For example in agricultural production, the farmers' efforts are recognized by the government by offering prizes to best farmers in different crop or animal production. In 1960s, the ministry of Health also used the prize offering as an incentive to improve on home steads in rural areas.

When the farmer has a forest on land which need to be protected, the government could compensate such a farmer by offering either food items or free education to his/her children.

Markets. One of the factors contributing significantly to the success of agriculture in Uganda is the readily available markets for agricultural products. Although Ugandans are being urged to take on tree farming there are no organized markets for most important products from forests like fuelwood. For example, fuelwood dealers are engaged in such a business because they are making enormous profits by offering very low prices to producers who are not motivated by such prices.

Transportation of forestry products is very important while considering marketing of forestry products. In order to optimize returns from their investments in forestry, farmers ought to be organized in such a way that they will be able to process one of their primary products in rural areas. For example, by carbonizing firewood to charcoal, both transport, storage and handling charges would be reduced significantly. By setting up a small scale of mobile sawmill and workshops in rural areas, it will not only create markets for primary forestry products, it will also create jobs and would help to bring about electrification of the rural areas.

CONCLUSION

Forestry will continue to play an important role in Uganda;s economic advancement. But in order to continue doing so, tree planting must occur at a rate which can check on the environmental destruction through deforestation. It is good that the present group of leaders in the country are talking about the dangers of environmental degradation through deforestation, and are urging Ugandans to plant trees, but more is needed than just talking and reassurances of government support. What is needed most is action, in:

formulating a forestry policy which identifies people's needs and demands for forestry products and which spells out solutions aimed at solving people's problems;

establishment of an effective forestry extension service whose officers will be able to form a link between the tree growers and users on one hand and researcher, and policy makers on the other hand;

offer economic incentives in form of loans, rewards and compensation, and marketing services.

It is action not mere words that will show government commitment to tree growing.

LITERATURE CITED

Chenery, E.M. 1960. An introduction to the soils of the Ugandan Protectorate. Department of Agriculture, Entebbe, Uganda.

Eggeling, W.J. 1945a. A review of some vegetational studies in Uganda. Uganda Journal, 12 pp 139-152.

Forest Department, 1955. A history of the Uganda Forest Department 1930-1950. Entebbe, Government Printer.

Hamilton, A.C. 1984. Deforestation in Uganda. Oxford University Press, Nairobi. p. 92.

Nicholson, J.W. 1929. The future of forestry in Uganda. Entebbe, Government Printer.

Sangster, R.G. 1951a. The forest dedication scheme in Buganda Province. Entebbe, Government Printer.

Sangster, R.G. 1951b. Buganda dedication scheme: Working plan for Indigenous Forests. Entebbe, Government Printer.

changes in use of a given forest area. So land use changes brought about by the constantly evolving preference and values in a developed economy can usually be accommodated within the existing main land use patterns. The types of change occurring can be classified as "luxury" and usually the economic importance becomes secondary to social cultural and especially ecological considerations. Usually, in these developed economies a well established set of policy tools, including legal instruments, exist to avoid unacceptable uses as well as to implement a land use plan embodying an ideal use of the land according to the wishes of the people at large and those impacted by that use. This public system of "Aménagement du territoire" ensures to some extent that non-market values as well as non-efficiency objectives are duly taken into consideration in the planning of land use.

In less developed economies, tremendous population growth coupled with low economic activities put great pressure on expanding the use of the land quickly. Settlement will convert forest into agriculture land and the development of a new infrastructure will open new roads opening accesses to area previously untouched by development. The land, often considered a free input and the only one available to many populations, is used very extensively with few complementary inputs. Land use patterns changes quickly under such conditions and are determined mostly by economic factors and sometimes under pressure of farming for survival. Generally speaking, the demand in most sectors of such economies is so high that the pressure on the land are continuously increasing bringing about rapid changes in land use which is guided mostly by economic considerations both nationally and internationally. Under such circumstances, master land use plans are difficult to establish as the situation evolved rapidly and the experience of planning is often lacking. While many attempts in devising such plans for the use of the land with different degree of details have been made, it is often difficult to control their implementation. Without effective policy tools, land use plans whatever their quality, will not be effective in implementing a desired course of actions concerning the use of the land to be developed.

The two situations of population and economic activities influencing the use of the lands described here represent only two extreme situations with most area of the world falling somewhere in between. Wherever the area of research is located in, we hope that the general framework that we are proposing and to which we turned now, will be of a general enough applicability that it can be referred to when reporting the results of research in forestry land use around the world.

A FRAMEWORK FOR RESEARCH

Due to the wide array of environments under which an integrated use of the land takes place, it has been necessary to propose a framework to look at research in this area in general terms. The framework should be helpful to describe, existing policies regarding the use of forest land as well as to evaluate them and to propose changes in policies and policy tools that directly or indirectly bear on the use of forest and other types of land. In order to accommodate the great variability of situations encountered around the world, it has been necessary to reach a level of abstraction allowing the inclusion of most situations in developed as well as less developed economies. On the other hand it was attempted to include all structural as well as functional determinants of land use change so that every possible and reasonable research questions could find a point of attachment in the proposed framework. The challenge is enormous. On one hand the framework should embody all the important determinants of land use changes which are numerous and intricate. On the other hand the model must stay simple and general enough to accommodate most situations of forestry land use under different environments.

While it was thought initially to propose two frameworks for the two antipodal situations described earlier, it was decided at the end to merge them and to underline the difference of some components of the framework when appropriate. It is expected that this frame of reference for research in integrated land use and forest policies will be improved over time by the scientists involved in this area of research.

THE FRAMEWORK STRUCTURE

It should be noted from the outset that the factor time has to be kept in mind when interpreting the framework which is given in figure 1. The present use of the land is explained in the first part of the flow chart based on the situation as existing now (components 10-220 of the framework) and its monitoring (230-240). An ideal integrated land use resulting from value preferences expressed through the political process, which components (250-320) are encircled in a box on the flow chart, will serve to delineate new land use policies for the future and to propose some policy tools to implement these policies (330-340). These changes will in turn create a new reality influencing land use. We are back now in the present through the loop 340-30 and all the process of explaining land use is reinitiated and proceed through another iteration according to the steps described in the framework. Land use planning is a dynamic process and a never ending one.

The political process by which new land use policies are set and implemented is central to the purpose of the new IUFRO working group S4.08-04. This decision making process is the central subject of forest policy research regarding the forestry aspects of integrated land use.

THE FRAMEWORK OVERVIEW

Before getting in any details concerning the different components of the framework proposed for ordering the reporting of international forestry research in integrated land use and forest policies, lets briefly review how these components relate to each other.+

Individual countries can no longer plan their future in isolation from the rest of the world. World land use suitability (10) will influence a country's land use through international network in transport, finance and particularly trade (20). Given a competitive international market for land products, and it is almost always more competitive than a national market, world land use will influence economic decision regarding land use at the national and local level. The degree of this influence will depend on the development stage and the population density of the country among other factors. For the given political economy of a country (30) and its land resources endowment (40), each sector of the rural economy reaches a balance of land products production and consumption which determines the price of these goods, mostly market prices (80, 100, 120),and services, often non-market prices (90, 110, 130), derived from different land uses. Non-market values will be more important in well developed economies.

These prices can then be used to calculate the B/C of alternative uses of the land for agriculture (140), forestry (150) or other sectors (160). The profitability of competing land use will be weighed along with other objectives which differ according to the type of ownerships: private (170), public (180), industrial (190), or non governmental (200). The weight of the economic objective is probably more important for country endowed with more resource per capita as well as for economies in their initial stage of development. From the multiplicity of land use decisions (210) results a given land use pattern (220) at a given point in time. This land use is monitored (230) to forecast change (240) and to serve as inputs to a possible land use plan.

Here politics start to influence the use of the land. The political process is more important and effective in guiding the use of land in developed economies and in countries in which the political process is well established and socially accepted. The present use of the land is assessed by the public and deemed more or less appropriate for different uses: agriculture (250), forestry (280) or other uses (270). As a consensus for land use preferences emerges and evolves over time (280), objectives and targets (290) are set tc establish a land use plan (320). These targets and plans are influenced by the monitoring (230) and forecasting (240) of past and future uses of the land but also by different private (300) and public or semi-public pressure groups (310). From the interaction of all these forces and the public and political will for change, emerges new land use policies (330) implemented through different policy tools (340), which are periodically evaluated (350).

At this point a new iteration is started as the new socio-economic and political environment (30) is changed to the extent that new land use policy tools have been effective in bringing about the desired changes. A new loop in the land use cycle is initiated.

FRAMEWORK COMPONENTS

Now that the overall land use framework and its dynamic is explained, lets go back to specify further some of the components particularly as they relate to the forestry sector. The world land suitability (10) can be described using general climate, soil, and vegetation maps or a combination of those with socio-economic factors such as made by FAO. A worldwide land classification would not be relevant to explain or plan the use of land in a particular country if it was not for the ever increasing interconnections that exist today between the different parts of the world (20). The law of natural resources comparative advantages of production should remain more true now than ever before as international trade of goods and services expands continuously. Yet those external influences can be buffered by economic strength, technological know-how or political will. Forest resources may be preserved for ecological, cultural, or strategic reasons. The amount of agricultural and forest goods internationally traded will reflect not only the potential of world land use but also economic and political considerations guiding the use of the land in different parts of the world (30).

The national land resources endowment (40) can be characterized by biophysical variables such as rainfall, altitude, topography (slope), soil types, depth and drainage, vegetation types and characteristics and other variables depending on the level of sophistication of the land classification and the information readily available. These biophysical characteristics of the land are related to the suitability of land for different uses.

As we said, the particular political and economical environment of a country (30) will influence the use of the land given its resources endowment. The importance of the quality of life, translated in a well kept environment, a fair income distribution or in other expressions of non-efficiency objectives, will be balanced with the concern for economic growth differently depending on the level of development of a particular economy. This balance will be reflected in the goals and objectives set for the different sector analyses (50-70) and in the market and especially non-market prices (80-130).

In its simplest form an analysis of the forestry sector (60), as for other sectors (50,70) includes a description of past and present consumption and production of forest goods and services, both timber and non-timber, in order to forecast into the future an equilibrium or a gap between them at the present and/or some higher real price scenarios. The ultimate goal of sector planning is to anticipate, to better avoid, relative price increases of the sector's goods and services. Difficulties arise in analyzing the forestry sector when one attempts to analyze the non-timber services provided by the forest use of the land (water, recreation, aesthetics.) In most developed economies the demand for these forest outputs increased faster than their supplies but often they don't have market values well established yet. For tropical countries, the ecological protection of the forest cover can be determinant for the sustainability of forestry and other rural sectors, particularly agriculture.

Based on the price forecast, developed in the sector analysis, the B/C analysis of different forest land uses and managements (150) will be made and compared within the sector and between sectors (140, 160) to channel investments in the most efficient alternative uses of the land. These investments will in turn contribute to bridge or narrow the gap eventually forecasted in the sector analysis between consumption and production of forest resources outputs. The B/C of investments in non-forestry uses of the land is based on the other sector analyses (50-70) and will compete with forestry uses. These investment analyses based on a strict efficiency criterion could induce a new use of the land or the intensification of the present use.

The difference in ownership, individuals (170), society (180), a firm (190) or a non-governmental organization (NGO), (200), affect the way benefits and costs are calculated for a certain use of the land. The valuation of the inputs and outputs, and the accounting of transfer payments also differ depending on the private or public point of view adopted for the analysis. Furthermore, the objectives in using forest lands as well as other lands can also vary with ownership. On public land all the objectives considered in the sector analysis (income distribution, ecological, cultural...) should also be considered when valuing the use of a parcel of public land. Private landowners adopt other objectives such as aesthetics, pride of ownership, financial security and recreation. Forest products industries do often consider the use of their lands to auto-supply their mills, satisfy the shareholders, diversify their portfolio and for other reasons. NGOs have been created to fulfil a specific mandate and so follow different sets of objective to evaluate the best use of their land.

From this multiplicity of decisions (210) results a certain land use pattern throughout the national territory (220). This pattern can be mapped using satellite imagery or aerial photos coupled with some types of GIS. The degree of details necessary to map land suitability and land use depends on the expected benefits to be derived from the mapping exercise.

Our biophysical environment (40) and its evolution, often deterioration (acid rain, vanishment of unique ecosystems, green house effect, ...), as well as the socio-economic and political systems (30) are in a permanent state of flux, and so is the use of the land. A monitoring of land use (230) permits to describe and explain past and present changes and to simulate its future evolution (240). These forecasts are necessary inputs to future sector analyses and to the political process influencing land use to which we now turn.

The changes emerging in the use of the land may not correspond to public expectations. The social assessment of the use of the land for the different rural sectors (250-270) reflects the present preference of land use (280). Through the political process, these preferences should translate in a redirection of land use toward a more socially desirable course. The political processes by which these preferences are translated in land use reforms varied across the world. Usually some objectives and targets reflecting the new land use preference are set (290) with many private (300) and public or semi-public (310) interest groups attempting to influence the goal setting procedure. If a reasonable consensus is reached between these political forces and the wishes of the public at large as well as the local population most impacted by the decisions at hand, a useful plan (320) of land use could be devised. The new land use plan can be more or less detailed depending on the national circumstances and should reflect well the overall new land use policies (330) which will guide the future use of the land for some time to come.

For these new policies to be effective in reorienting land use, they need to be implemented by effective policy instruments (340) such as clear land ownership, public acquisition, transfer of land rights, reordering of land ownership, law and regulations, persuasion, taxes and incentives. A procedure to evaluate (350) the efficacy of such tools has to be undertaken at their initiation and during their implementation.

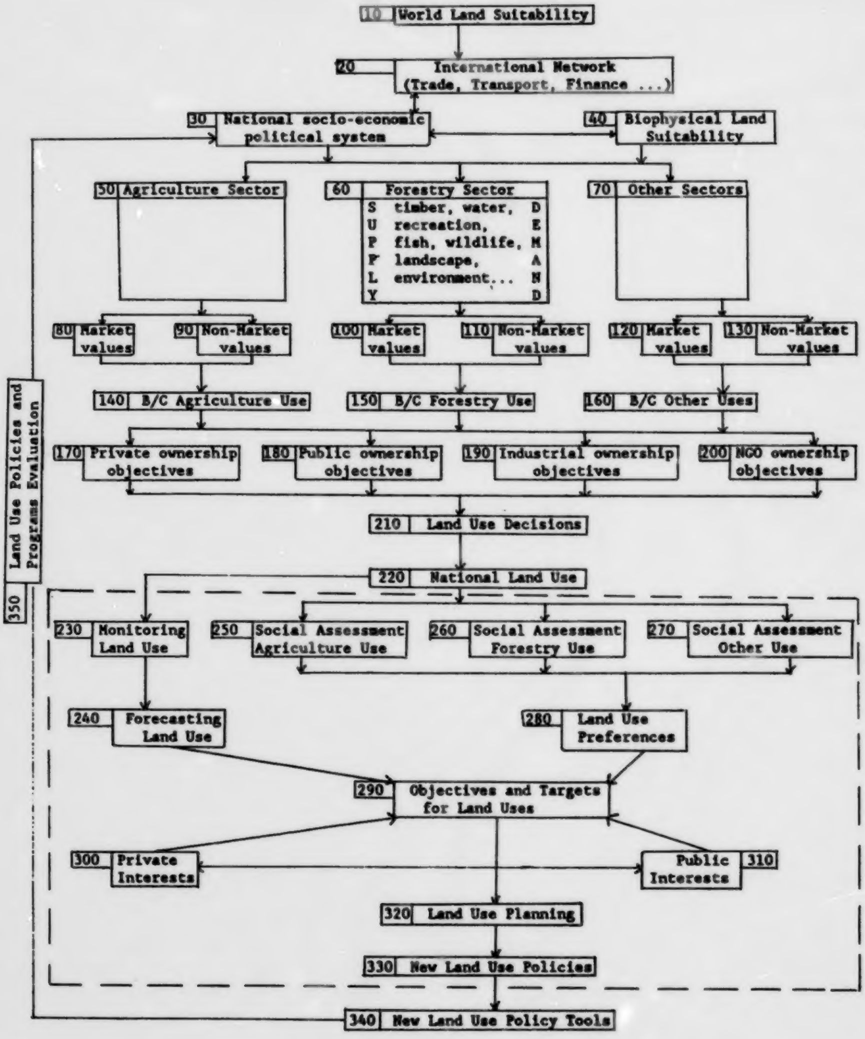
Then, and to the extent that the political process (230-340) is efficient, the socio-economic and political environment (30) should be changed so that it induces a shift in land use in the desired direction through the process described in the framework. A new iteration in the FILUFP (Framework for Integrated land Use and Forest Policies) is initiated.

CONCLUSIONS

There are many different ways to link in a general framework all the important subjects of research related to integrated land use and forestry. We propose one that duly takes into considerations the political and economic aspects impinging on the biophysical suitability and the sustainability of the land for forestry and any other use of the land throughout the world. It is recognized that the differences in economic development, population growth, ecological and environmental characteristics, culture, and socio-economic and political systems, force to emphasize some components of the framework over others depending on the area of the world we are working in. This is what we strive for, to achieve a model which is complete but general enough to encompass most situations encountered throughout the world.

Different realities and philosophies regarding land use planning exist. Some favor a highly controlled use of the land while others are satisfied with broad guidelines letting much room for manoeuver in guiding the use of the land. A good middle ground exists between these two views. For land under public ownership detailed plans are recommendable to allocate resources to different uses especially in the absence of market signals. The land under private ownership could be guided by general principles and broad land use plans derived from accepted policies constraining some uses of the land but letting other mechanisms such as local involvement, market forces , new environmental perceptions, to establish or change the use of private land as seen appropriate and feasible over time. Land use policies and their resulting plans to guide the management of public and private lands should be flexible enough to allow for a timely response to our ever changing biophysical and socio-politico-economic world.

Figure 1 - A Framework for Integrated Land Use and Forest Policies (FILUFP)


10 World Land Suitability
20 International Network (Trade, Transport, Finance ...)
30 National socio-economic political system
40 Biophysical Land Suitability
50 Agriculture Sector
60 Forestry Sector
S U P P L Y
timber, water, recreation, fish, wildlife, landscape, environment...
D E M A N D
70 Other Sectors
80 Market values
90 Non-Market values
100 Market values
110 Non-Market values
120 Market values
130 Non-Market values
140 B/C Agriculture Use
150 B/C Forestry Use
160 B/C Other Uses
170 Private ownership objectives
180 Public ownership objectives
190 Industrial ownership objectives
200 NGO ownership objectives
210 Land Use Decisions
220 National Land Use
230 Monitoring Land Use
250 Social Assessment Agriculture Use
260 Social Assessment Forestry Use
270 Social Assessment Other Use
240 Forecasting Land Use
280 Land Use Preferences
290 Objectives and Targets for Land Uses
300 Private Interests
310 Public Interests
320 Land Use Planning
330 New Land Use Policies
340 New Land Use Policy Tools
350 Land Use Policies and Programs Evaluation

INTRODUCTION TO SESSION ON POLICIES INDIRECTLY AFFECTING INTEGRATED LAND USE AND WATERSHED MANAGEMENT AND THEIR ROLE IN SUSTAINABLE DEVELOPMENT

Patrice Harou and Hans Gregersen (Moderators)

(jointly sponsored by
S4.07-03, "Integrated land use and forest policy,"
and by S4.08-04, "Socio-economics of
integrated watershed management.")

Tuesday, August 7, 1990
14:00 - 16:00

FDC: 916: 116: 903

There are a number of obvious ways in which government policies directly affect watershed management and forest land use. For example, there are direct land use controls, private forestry regulations, government timber harvest policies, etc. These direct effects have been studied quite widely and quite thoroughly in many cases, e.g., in the case of taxation of land and timber resources.

However, policies also affect indirectly the integration of land uses in an overall watershed management context. By indirectly, we mean in ways that are not within the scope of the particular policy being considered. For example, a policy providing high agricultural price supports may encourage clearing and farming of marginal lands that should have been kept in forest or other permanent vegetation cover. Increased erosion occurs and resulting in increased rates of siltation of a downstream dam reservoir with consequent reduction in hydropower production, flood protection, etc. These are indirect effects of the policy.

These indirect impacts can have a significant effect on the overall sustainability of development in a country or region. Yet they have not been studied in nearly as great detail as in the case of direct impacts. Thus, the purpose of this session is to explore the dimensions of such indirect policy impacts and to establish a realistic agenda for research, given the difficulty involved in identifying and assessing such impacts.

The following types of policy interactions and externalities are of interest:

* Conflicting responsibilities among government agencies create negative policy externalities. High level government policies often fragment responsibilities for guiding land uses in a watershed, and this can result in conflicts in land use, e.g., 1) one agency is providing incentives to protect wetlands, another agency is providing incentives to convert them to other uses; or 2) an agricultural ministry ignores downstream impacts of upstream activity since its authority is separate from the public works ministry that controls and works with dams and urban water related projects downstream.

* Policies put forth by an agency can have unanticipated indirect impacts in its own area of interest and responsibility. The externalities due to agricultural price support policies mentioned above provide an example. In addition to the effects mentioned above, reduced capacity in the dam reservoir can affect downstream irrigation. Thus, a policy to help agriculture eventually hurts agriculture.

*The forestry sector analysis objectives and targets may have been set without due considerations to the policies set for other sectors, especially agriculture. Such oversight can change the future forest area available and consequently the forecast of timber supply. Such lack of intersectoral coordination may affect timber price as well as the amount of investment required in the forestry sector if more land shifts from forestry to agriculture. An opposite situation could also happen.

In sum, the questions which we hope to address are the following: i) what types of policy interactions or externalities are important for forestry, both in a positive and in a negative way? ii) how can such interactions/externalities best be studied? iii) how will such interactions have to be considered in integrated land use?

Two keynote papers will address the general issues for research. These are:

* McGaughey, Stephen (InterAmerican Development Bank, U.S.citizen)
Forestry and natural resource policy linkages: issues for research

* Harou, Patrice (Univ. of Mass., Belgian); and Hans Essmann (Albert-Ludwigs Universitat, BRD)
Integrated Land Use and Forest Policies: A framework for research;

These papers are reproduced in this proceedings. In addition the session will include papers by Ronnie deCamino (Chile), Keshav Kanel (Nepal) and William Gombya (Uganda) that will deal with specific issues. At the time of printing, only the summary of deCamino's paper was available. That is included here.

FOREST SECTOR AND NATURAL RESOURCE POLICY LINKAGES: ISSUES FOR RESEARCH

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FDC: 903: 901--01

SUMMARY

Both national and sector policy considerations need far greater attention in forest sector, natural resource and environmental research. A framework is presented for identifying the most important policy issues. Central to future research is the identification and analysis of the multiple policy linkages among sectors, and the direct and indirect consequences on natural resource and environment management and protection.

Key words: forestry policy, policy research, policy issues, sector linkages

THE MOUNTING POLICY CONCERN

Since the early 1980's there has been an increasing interest among international development institutions in the effects of economic policies on national and sector economic growth and development. This accent on policy management and adjustments has given rise to new types of international support for national development programs, notably through what is called nonproject or policy adjustment lending.

This lending takes the form of national economic structural adjustment loans, sector policy loans or loans to finance international trade. These loans are characterized as fast disbursing, containing conditions on policy changes and criteria for institutional adjustments during the life of the loan as preconditions for the loan disbursements (called tranches).

The fundamental notion behind policy lending is that policy changes should be given equal or greater attention than traditional project loans in affecting change in growth and development processes. Also, lending for policy changes is thought to be just as productive as investments in (say) infrastructure. It is also argued forcefully that project lending, e.g., in a particular sector, cannot be effective without an appropriate set of national and sector policies. Nonproject financing makes possible the policy adjustments that provide the underlying conditions for project progress. But project lending continues to be very significant, as it is the bulk of the lending of the multilateral and bilateral institutions.

Simultaneously with the expansion of multilateral support for national policy adjustments, there has been a manifest acceptance of environmental and natural resource protection and management as a fundamental goal of international finance. Also, many national governments are incorporating environmental protection programs and policies in their development plans, and the international community is seeking to increase its support for these programs.

Thus the current concern for understanding exogenous policy effects on the forest sector, natural resource utilization and the environment is a extension of the wide recognition of the influence of policy adjustments on the performance of agriculture and other major sectors. It became clear to observers that national policies were also having perverse effects on the environment and natural resource use. Similarly, there has been some criticism of the approaches that have been employed in specific sectors, such as forestry (e.g., the TFAP), in designing development programs without giving enough attention to policies.

The forestry sector has been a leading sector in the changing concern with natural resource protection. Most multilateral and bilateral programs have had active forestry programs since the late 1970's. Internationally, the Tropical Forestry Action Plan (FAP) was created (in 1985) by the major donors to assist national governments in identifying new projects and programs for forestry, the environment and natural resource development and protection. International donors (at meetings Bellagio I and II) agreed to initiate the financing of forestry research on an internation scale. Following the Bellagio forestry meetings the Consultative Group for International Agricultural Research (CGIAR) incorporated forestry research as one of its principal mandates.

The TFAP uses several programmatic areas within which the sector's problems, projects and programs are viewed. The first five fields (below) define the major sector relations. These are:

(1) forestry and land-use,
(2) forest-based industry,
(3) energy and fuelwood,
(4) natural resource protection and biological diversity, and
(5) institutional development.

The author adds to these five TFAF programmatic areas two separate essential policy and program ingredients: namely,

(6) international and national finance, and
(7) economic policy.

Together these seven program and policy areas establish the elements of a simple framework for examining the interrelationships, i.e., the direct and indirect linkages, between the forest sector (very broadly defined), the environment, natural resource management and protection functions, other sectors and national and international economies.

There is a need to mobilize international support for the forest sector, and environmental and natural resource management and protection

(iii) how to expand forestry investments in soil conservation and watershed management programs; and

(iv) how to evaluate the impact of new forestry management and production technologies, especially by introducing agroforestry into local farming systems for multiple-use forestry.

Each of these issues provides a view of the linkages, in which the current and future competition for limited land resources is the central variable.

Forest-based Industry

The forest-based industry is linked with the forest sector itself by its purchases of timber inputs, to the industrial sector through its direct sales and purchases of inputs from other industries, to the transport sector, and to other sectors that make purchases from it, such as mining and construction. Because of the connection between land-use and industrial roundwood supplies, forest industry is also linked to agriculture and energy.

There are many substantial program issues for the forest-based industry linkage analysis. They include:

(i) the role of forest industry in international trade, both exports and imports;

(ii) establishing effective mechanisms for private investment, participation, control, management and ownership of forest resources and industries;

(iii) making investment and designing incentives for plantations, and encouraging better utilization of existing forest resources for industrial timber resource development,

(iv) delimiting the role of small-scale industry and the development of appropriate technology for this scale of industry;

(v) determining the impact of national industrial and economic policies on forest-based industry; and

(vi) determining the environmental impacts of industry production and waste management on land-use patterns, especially downstream.

Energy and Fuelwood

The forest sector is very closely linked to the welfare of rural households through its provision of fuelwood. The rate of fuelwood use is especially related to natural resource supplies and prices. For example, the energy crisis of the 1970's more industries began to use locally available forest-based energy. As a consequence the energy value of the forests rose and the scarcity of fuelwood became a concern for forest sector institutions.

The energy contribution of the sector is also an issue for land-use planning because of the trade-off in the use of forest lands for agriculture and the destructive consequences for the remaining forests of unbridled fuelwood harvesting.

Some of the policy issues for energy and fuelwood linkage analysis are:

(i) integrating better fuelwood energy production with multiple-use social forestry and agroforestry programs;

(ii) establishing programs and price incentives for energy conservation through the more efficient use of fuelwood and the substitution of wood by other (mainly fossil) fuel sources; and

(iii) designing the organization of fuelwood and wood energy programs by farmers, local communities and commercial industrial enterprises.

The principal linkages are with the energy sector itself, communities and households, the industrial sector and agriculture. Policies in any of these sectors can shape resource and energy utilization elsewhere in the economy.

Conservation and Biodiversity

There are many linkages among conservation activities in forests and the policies and programs in agriculture, tourism, rural and urban households and mining and industry. Indirectly, there are global and long-term (today still undiscovered) benefits to mankind to be derived from the genetic resources that are protected there.

Some of the significant conservation strategy issues of the forest sector are:

(i) the selection and management of conservation areas using acceptable scientific, economic, ecological and social criteria;

(ii) designing development plans so land-use patterns and production activities of other sectors, especially agriculture, can coexist with the protection and conservation areas, and

(iii) recognizing the value of the non-timber benefits of the natural forests along with the long-term gains to be obtained from their protection.

Hence, there are conservation linkages to many sectors, policies and institutions, including agriculture, tourism, energy, industry and mining.

Institutional Improvements

This includes all of the main themes of organizational support for the forest sector and natural resource programs, and the natural resource and forestry management activities of other sectors. A wide range of institutional services are needed to execute a sector-wide action program.

The most critical issues in the design of the policy linkage analysis of the institution program include the following:

(i) how to increase the cadre of trained personnel for the forest sector and natural resource management activities, and how to introduce better personnel management (e.g. adequate staff salary and nonmonetary incentives);

(ii) how to integrate local, community and regional sector and national interests into forest and watershed administration and action programs; and

(iii) how to incorporate active voluntary resource protection and management by the private sector.

Many sectors and institutions work with local communities and policy analysis must ascertain the existing capacity of these programs and the prospects for better attention to resource management.

Finance

One of the chief policy problems for natural resource management activities is how to increase domestic and iternational financing of the programs of land-use, forest based natural resource-based industry, energy, fuelwood, and resource conservation and protection.

Many countries have severe restrictions on domestic financial resources because of domestic and international economic problems, such as the decline in the international prices of their exports and the foreign debt crisis. The internal policy adjustments that they have imposed for financial austerity have increased the problems.

Under these financial constraints, it is difficult for the forest and natural resource sectors to expect preferential treatment unless they can demonstrate reasonable economic returns. For example, proposals for special financial incentives for forestry investments--industrial plantations, social forestry and national park expansion--require that financial authorities understand the economic benefits that flow from these investments.

Three financial issues that illustrate the need for policy analysis are:

(i) designing optimal financial incentives for forestry and natural resource investments by the private sector;

(ii) ascertaining the viability, cost and direct and indirect impact of public subsidies on land-use and natural resource management; and

(iii) allocating domestic and external financing among competing sectors and within the natural resource sectors and the environment.

The policy analysis should contain a view of the present financial mechanisms and constraints and the methods to increase the impact of the scarce financial resources on the environment.

Economic Policy

Macroeconomic policies in developing countries have changed rapidly during the 1980's, but (with some exceptions) policy studies of the forest sector, natural resources and the environment have had a narrow policy focus. Macroeconomic and sector studies in agriculture and industry have shown that national policy decisions strongly shape natural resource use in a country. There are too few examples of national forestry or natural resource planners studying the effects of national economic policies on their own activities.

The significance of so-called "non-forest or nonresource" policies has been demonstrated. In the forest sector (and spilling over into watersheds) country surveys show that the non-forest incentives for deforestation and the large private returns from forest concessions and exports produce limited economic and financial returns to the national economy. Few studies have shown the cost to the economy of the loss of its natural resource base by these policy causes.

There are two broad categories of policies that need to be included in forest sector, natural resource and environmental policy analysis:

(i) non-forest sector or non-resource policies, including international trade restrictions, taxing and spending, finance, interest rates and capital, labor, foreign investment, ownership and common property access and use, and policies for energy, agriculture, industry, mining, transport, construction, among others; and

(ii) forest sector and natural resource polices, encompassing stumpage charges and other resource pricing arrangements, forest and natural resource concession agreements, royalties and fees, forest industry investment regulations, export rules and incentives, and regional development policies.

This is not a comprehensive list, but illustrative of the policies that the natural resource programs should considered.

A RESEARCH AGENDA

There is a substantial future research agenda for the forest sector and natural resource issues, policies and programs. Forest resouce and environmental analysts have discovered the significance of many general economic and financial polices for the use and protection of the environment and renewable natural resources.

First, the sector policies themselves have been shown to been wanting and they have encouraged the improper utilization of natural resoures and the increase in evironmental degradation in many countries. Second, it appears that many policies of other (non-forest) sectors may be directed against the long-term rational use of natural resources and for environmental protection. The agricultural sector is an example.

Selected areas of research needs are outlined briefly. The research topics are shown under the headings of (i) sector economic policy impacts and linkages; (ii) costbenefit analysis and environmental impact analysis; (iii) natural resource and environmental institutions; and (iv) sector financial policies and linkages.

Under category (i), economic policy impacts and linkages, there is a enormous amount of research to be done. In the sector there is a need to improve its own policies (the policies over which the sector institutions have control) in order to promote and finance better resource uses. Since Since many countries have had policies that have been antithetical to resource protection, the identification of indirect and direct policy linkages and interventions is a formidable task.

Another category of policy studies refers to the direct and indirect impact of non-resource policies on resource use. It must be recognized that there are severe limits on changing many macroeconomic and sector policies that are detrimental to the environment. This is because the general policies are undertaken for many reasons that go far beyond the economic significance (at least in the short-run) of the damaged sectors. The broader policies have been conceived without regard for the side effects that they might have on the environment and natural resource use. Also, multilateral policy adjustment lending may have unwanted indirect effects on natural resource use and the environment.

A related topic is in the design of compensating policies that counteract the macroeconomic and sector policies that are detrimental to natural resource protection and management. Since many general policies cannot be modified for the benefit of a specific region, program or sector, then a local or sector compensating principle would be appropriate. While such solutions are second best, they recognize the reality of policy formulation.

In the category (ii) of cost-benefit analysis, many research subjects are current. First, there is a urgency to improve the economic analysis of natural resource management and protection investments. There are some who assert that economic analysis is unecessary for natural resource and environmental activities--they are justified on their own merits. This notion that environmental investments should not meet that same economic tests as investments in other sectors seems to have a growing acceptance. If one sector is considered exempt from the basic rules of resource allocation then there are likely to be many other sectors (and there are) that demand the same special treatment. It is incumbent on resource and environmental economists to find practical methods for social cost-benefit analysis.

A part of the solution in improving the cost-benefit analysis of environmental activities is to improve the measurement of externalities and unrecognized benefits such as non-timber benefits of forests. Since there has been a tendency recently to make much of these benefits, it would be desirable to quantify them, and formally measure their social and economic contribution.

A third category, (iii), concerns the institutional requirements of formulating and organizing natural resource management and environmental policies. The subject of institutional reform is too large to be dealt with here.

Further study needs to be conducted on three levels. The first is how to organize natural resource and environmental programs within traditional sectoral institutional models. It might be suggested that entirely new types of institutions are needed. Clearly, forestry agencies in many country are not capable of assuming the wide functions that are demanded of them to promote, protect and organize resource activities.

The second concern is that most of the natural resource management agencies have virtually no capacity to do the economic and technical studies that are needed to create the new sectoral and regional policy environments. How to set up the policy studies, and what policies to begin with are fundamental allocation problems for public agencies.

A further concern is how to incorporate into national programs the management efficiencies and higher levels of motivation that are more often found in the private sector, in profit or not-for-profit organizations. How to bring together the public responsibilities with the private action capacity is a organizational question that needs further analysis.

A final category of research on (iv) sector financial policies and linkages should cover several significant operational issues. One is to determine the optimum rates of government subsidies for natural resource programs and private investments. The use of public financial subsidies - (tax reductions, direct payments, in-kind contributions) are widely used and accepted in the forest sector. This experience could be usefully expanded to programs for natural resource and environmental programs, that have large externalities or high rates of risk which discourage private action.

A second issue, related to the first, is how to mobilize private interests (producers, workers, NGO's, etc.) in favor of natural resource conservation programs. The examples from the public sectors in many developing countries suggest that governments alone do not have the human resources and finanicing to undertake large-scale resource management and protection programs. How to encourage private actions is a central institutional and financial question for research.

METHODICS AND USE OF ECONOMIC EXPRESSION OF PRODUCTION AND NON-PRODUCTION EFFECTS OF FOREST STANDS

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SUMMARY

With the development of multi-purpose forest management the method of forest appraisal is further improved. Above recommended method follows the aim considering the results of purposive foresters activities at the development of productive and non-productive forest functions on the basis of objective quantification. To state the productive component of appraisal rate, we have chosen the coefficient of total mean increment. The profit of non-productive effects is expressed by comparison of percentual parts of prominence to timber production value determinated by evaluation of total mean increment.

Keywords: Forest appraisal, multi-purpose forest management productive and non-productive forest functions

The purpose of the forest stand appraisal is decisive for chosen methodical approach. The methodics finding out the capital values of annual or periodical net yields of forest lands are best. Traditional forest appraisal, novelized and improved by the application of modern mathematic-statistical methods and computer use, serves in the marketing conditions for expressing the level and changes of forest property value, regardless of the form of ownership.

With the development of multi-purpose forest management, putting out mainly the emphasized non-productive forest functions, the method of forest appraisal is futher improved. The mere comparison of economic inputs and outputs measured by common productive criteria is not often sufficient for evaluation of administration efficacy in forestry. Apart from timber or tree biomass production, the non-production forest effects are the results of economic activity. The method of complex financial appraisal of useful functions of forest stands can be used for complex expression of the results of economic activity in their dynamic development.

Above recommended method follows the aim considering the results of purposive foresters activities at the development of productive and non-productive forest functions on the basis of objective quantification.

To state the productive component of appraisal rate, we have chosen the coefficient of total mean increment which informs best of changes in quality of forest resourses from productive aspects. It expresses a mass volume proportion produced by forest stand during one year of rotation period.

Total mean increment, besides rotation period, depends on tree species, site class and stand density. Running positive or negative changes of factors (taxative values), influenced by the level of total mean increment occurring during evaluated period, express productivity changes of respective forest properties. These changes, are usually as a result of economic measures, realized in a given period and docummented by forest management.

Factors influencing the increment enable to shorten the interval of state evaluation of forest property and to utilize mentioned evaluation methods for operative management of forest enterprises.

For increment financial appraisal, the current market prices of raw timber assortmens are usually used. For more precise increment value expression, the stumpage prices (market prices minus productive costs - cutting and transporting) should be used. Considering that the production costs are strongly influenced by a lot of temporal variable factors, market prices are sufficient as comparison criteria for calculation of financial increment value. The main condition for increment appraisal is to use the same purchase prices at the beginning and in the end of evaluated period.

The appraisal of forest resources value can be provided in other forms. It can be based, for instance, on changes of values of growing stock, to react in this way, apart from stocking, site class, and tree species composition changes, to the changes of stand age composition. The stands of the first, second and third age category, where the growing stock according to current methodics is not stated, are not included in information set. In the stands of these age categories silvicultura measures are of the main importance, the coefficients of total mean increment are preferred at an assessment of production state of forest resources, therefore.

Present conditions of increasing public interest in ecological and social influence of forest stands are not always sufficient to evaluate foresters activity, taking in account only the results that he gained while developing productive functions of forest resources. Determination of non-productive component of appraising rate is in fact more complicated than that in preceding case during evaluation of productability development. The public of experts is conversant with true obstacles, connected with appraisal of non-productive effect. At the same time, numerous methods for evaluation of non-productive functions, as they are mentioned in professional literature, proceedings and IUFRO publications, are well known.

In our opinion, above-mentioned obstacles are mainly caused by difficulties with measurements of physical size of corresponding effect, and meanwhile, it is impossible to determinate independence on realization of silvicultural biological or technical measure. The fact of non-market realization of non-productive activity of forestry is also of great importance. Ecological and social forest functions, except few ones, are free of charge and are provided for society or its components by owners without compensation of costs necessary for their development. Those functions are provided with forestry means only if productive and non-productive forest functions are paralelly developed. The development with a view to non-productive forest functions are most frequently financed from social means of communal and regional organs or straightly from state budget.

Therefore, the author's evaluative method is rather simplified, but fitting the goal. The method is based on comparison of different significance of single non-productive functions in diverse conditions. This comparative method with acceptable subjectivity appreciates the profit of non-productive effect, comparing percentual parts of prominence to timber production value determinated by evaluation of total mean increment. The most highly evaluated, according to the method, are forest stands with the highest values of non-productive functions (mountain protection forests, forest with important hydrological functions and recreational forests), whose real production - total mean increment approaching to potential productive capability responding to a site type.

Estimating non-productive effects (percentually to the timber production value), it is necessary to consider, if relevant effect is comming out spontaneously or as a result of special biological or technical measures not connected with development of timber production. The non-productive functions are significant and therefore, preferred.

In Czechoslovak conditions evaluation of non-productive forest functions based on above mentioned method is value 0,4-10 times higher than prices of wood production. Evaluation of purposely developed non-productive effects in protective and other specialized forest regions is often significantly much higher than evaluation of parallelly arisen effects.

Economic expression of productive and non-productive effects of forest stands characterises the changes in state of forest resources. Evaluating rate is a criterion of social value of forest property independent of market factors, operation forest ownership form and owner's subjective aim of economic activity. This evaluation cannot substitute economic criteria periodical classifying economic management results. Above-mentioned evaluation exclusively expresses theechanges in a social value and forest significance.

Analogically, it is possible to evaluate the damage, or in a broad meaning, the social loss caused by influence of negative factors to forest biocenosis. The subjects responsible for inception and influence of mentioned negative factors are in different countries with different accent economicaly affected. It is obvious that it is necessary to distinguish between economic penalty for damage caused by the owner (including organizations responsible for the management) and reimbursements for universal damage. The sanctions against forest damage (stricter taxes, reimbursements for wrong out-law management or temporary and permanent deforestation) are the expression of the social interest in maintaining and developing non-productive forest stands functions. The reimbursements level shoulddepend on social importance of non-productive forest functions.

ESTIMATING THE ECONOMIC VALUE OF SUBSISTENCE HARVEST

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SUMMARY

This paper reviews theoretical and practical considerations for application of economic methodology to estimate the value of subsistence harvest of forest products. Demand for subsistence harvest is defined as the sum of demand for the end product and demand for the harvest activity. The observation of market behavior, alternative cost, travel cost, and contingent valuation methods are examined. Some methods ignore the value of the activity. Most methods can provide useful information about the marginal values of harvests, but may be of limited utility in estimating the value of large nonmarginal changes, such as in the right to harvest.

Keywords: markets, substitute cost, contingent valuation, cultural value.

INTRODUCTION

Knowledge of the economic value of forest products (timber, wildlife, etc.) is useful in setting public policy. Neoclassical economic methodology includes powerful tools for estimating the value of resources, including forest products. However, can these methods be applied to determine the economic value of resources harvested in the context of a subsistence way of life? If this is possible in general, can we measure total as well as marginal value? Further, if economic valuation methods can be applied in this context, what then are the limitations of those methods?

These issues recall a complex controversy about the applicability of the neoclassical economic paradigm to understand the workings of primitive and peasant nonmarket-oriented economies. Some authors in economic anthropology, such as Karl Polanyi (1944) and George Dalton (1971), argued that the economic tools developed to understand highly developed market economies are of limited use in understanding economies lacking markets and a generalized medium of exchange, and that the cultural and social constraints placed on individuals in some economies so constrain or direct behavior as to seriously limit the applicability of neoclassical economic theory. Without disputing this claim, it is assumed herein that, in many contemporary economies containing subsistence sectors (e.g., late 20th century Alaska, see Brown and Burch 1989), subsistence users have probably had sufficient interaction with markets to allow application of neoclassical economic valuation methods. Whatever the characteristics of subsistence-based economies were in earlier times, the growing participation in the market economy, with its concomitant attenuation in the importance of reciprocity and redistribution, has in many locations created situations where comparable economic values can be determined.

"Subsistence" typically refers to a minimum level or standard of living for physical and mental survival. Some authors extend the concept to include not only survival, but also "productive efficiency," which brings in the minimum requirements for "productive living" in society (Sharif 1986). In the context of natural resource management, however, subsistence often refers to customary reliance on harvest and personal use of renewable natural resources to provide for a significant portion of a family's needs. Such customary reliance is found, for example, among Natives of arctic North America, and among rural populations of many developing nations. This paper adopts this latter meaning of subsistence.

ECONOMIC VALUE IN THEORY

Economic valuation within the neoclassical economic paradigm incorporates a fundamental distinction between efficiency and equity. Efficiency deals with the allocation of goods and services *given* the distribution of income. Equilibrium price, an economic measure of value, is determined in a market by the interaction of demand, based on willingness to pay; and supply, based on marginal cost. Willingness to pay (WTP) is of course constrained by ability to pay, such that the number of "votes" a market participant has in the determination of economic value depends on his or her income -- the greater one's income, the greater one's potential influence on economic values.

Equity deals with the fairness of the income distribution. The unfettered effects of a competitive market system are often altered by governments who desire a more equitable distribution than would otherwise occur. Mechanisms for affecting income distribution include income transfers via progressive taxes, as well as the preferential use of natural resources by subsistence users.

Because demand and supply, and therefore economic value, are based on the existing distributions of income and property rights, alternative distributions may yield different estimates of economic value. This fact is of particular importance when considering the effect of subsistence users' WTP on measures of economic value, because subsistence users are likely to have relatively little cash. And the low WTP that a lack of cash causes may not reflect a lack of assigned value in a broader sense. Indeed, by remaining in a rural setting, and foregoing the steady income that a city job could provide, the subsistence user may be indicating he assigns considerable value to his way of life. Yet it is that high value placed on the rural, subsistence way of life that precludes the ability to pay much in cash for the resources on which that way of life depends. Thus, economic value information should be considered by policy makers in light of equity considerations.

value results from the choices of individuals, who are free to express their held values in their choices.

However, this stance must be qualified in three ways. First, where value is measured in WTP terms, and that willingness is so constrained by ability to pay that cultural values are overwhelmed by more basic needs, monetary estimation of value may place some groups at an unfair disadvantage. As stated earlier, value estimated within the economic efficiency framework accepts the income distribution as given.

Second, the economic model assumes perfect information -- that people are aware of their options and the impacts of their choices. Yet, the long range impacts of current choices are rarely obvious. Furthermore, individual choices may have a combined effect. A series of discrete, small (i.e., marginal) choices may collectively cause lasting changes to one's life or a people's culture that were not anticipated at the times of the choices. Unintended consequences may be particularly likely where the choices involve goods such as wildlife which, to some subsistence harvesters, are not only inputs to physical well-being, but also symbols around which cultural identity and cohesion revolve.

Third, some large nonmarginal changes in resource availability may be beyond the purview of economic valuation. To take an extreme example, a change that eliminated the opportunity to practice one's religion could not, for most people, be accurately valued in economic terms. There is no clear rule for distinguishing what changes are within, versus outside, the purview of economic valuation, but a strong case could be made that changes which significantly threaten a people's cultural heritage are outside that purview.[4]

ESTIMATION OF ECONOMIC VALUE

Methods for estimating the economic value of resource changes include (1) observation of market behavior, (2) the alternative cost method, (3) the travel cost method, and (4) contingent valuation.

Observation of Market Behavior

In the absence of a commercial market in which to sell his product, and in absence of policy constraints on harvest, we would expect a subsistence user to produce at the level where his marginal willingness to pay/sell equals his marginal cost. This would correspond to production of Q_1 in Figure 1, where demand (D_h) equals supply (S_a) at price P_1. Now, if there were a commercial market for this good, with an established price, the user might participate in this market, depending on that price, his costs, his personal demand schedule, and his transaction costs (the costs of participating in the market, including both out-of-pocket costs and any costs imposed by cultural or social pressures or legal constraints). Assuming zero transaction costs, the harvester would be expected to sell some of his take if the wholesale price were greater than the marginal value of the product to the harvester in the absence of the market (if the wholesale price were greater than P_2 in Figure 1). Similarly, the harvester would be expected to purchase some of the product if the retail price were less than the marginal value of the product to the harvester in the absence of the market (if the retail price were less than P_2 in Figure 1).

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[4] While some goods may not be amenable to economic valuation, decisions may nevertheless need to be made that require consideration of tradeoffs involving such goods. Incommensurability of value makes tradeoffs difficult, but does not preclude their consideration. See Krutilla and Fisher (1975) for examples of how tradeoffs among incommensurables can be evaluated.

If an established wholesale market existed, and we observed no sale by the harvester in the market, we would assume, ignoring transaction costs, that the gross marginal *product* value to the harvester was probably greater than, but possibly equal to, the wholesale price. But, if the harvester sold part of his take, his action would indicate that, to him, the gross product value of the sold portion was equal to the wholesale price. But the wholesale price would underestimate the gross value of the portion retained (it is retained because its value is greater than the price available from sale).

Similarly, if a retail market existed, and we observed no purchase, we would assume, ignoring transaction costs, that the gross marginal value of the *product* was less than, but possibly equal to, the retail price. But if the harvester purchased some of the product, his action would indicate that the gross value of the product to him was equal to the retail price. And if both wholesale and retail markets existed and the harvester neither sold nor purchased the product, we would assume that the marginal value of the *product* to the harvester was within the range from the wholesale to the retail price.

The key features in allowing us to draw inferences about a seller's (or buyer's) marginal product value from his market behavior are that (1) he is a price taker (he cannot affect the price) with good information about the price and (2) the product is homogeneous and divisible. A fully competitive market is not necessary to indicate value; for sale, only the seller's side must be competitive, and for purchase, only the buyer's side must be competitive.

We have observed that market behavior may indicate the value the harvester assigns to the product. However, the price at which a harvester purchases or sells the product does not necessarily indicate the value of the *activity*. If the value of the activity is positive, market price of the end product will underestimate the value of harvest. If sale is observed, the gross marginal value of the harvest is assumed to be equal to the sum of the wholesale price and the marginal value of the activity (D_a at the current harvest level). If purchase is observed, the gross value of the harvest is assumed to be equal to the retail price plus the value of the activity. If the value of the activity is substantial, basing estimates of a loss of harvest solely on observation of market sale or purchase of the end product underestimates the loss to the harvester.

Table 1 summarizes inferences about economic value that can be drawn from observation of market behavior, assuming the good may be sold competitively at price P_w and purchased competitively at price P_r, where $P_w < P_r$ and transaction costs are nil. For each possible observation (sale of some or all of the harvest at price P_w, supplement of harvest with purchase at price P_r, or no market participation), the table lists the gross economic values applicable for valuing reductions in harvest. These indications of economic value apply whether or not the pre-reduction harvest level was already constrained below the harvester's optimum level.

Table 1: Indications of value of harvest given observation of behavior in wholesale and retail markets.

Observation	Economic Value
Sale at P_w	$V_h \geq P_w + V_a$
Purchase at P_r	$V_h = P_r + V_a$
Neither sale nor purchase	$P_w + V_a \leq V_h \leq P_r + V_a$

V_h in Table 1 indicates gross value to the harvester per unit of harvest. V_a indicates gross value of activity per unit of harvest. For marginal changes, V_h and V_a indicate the values of D_h and D_a, respectively, at the pre-change harvest level. For nonmarginal changes, V_h and V_a indicate the average values of D_h and D_a, respectively, over the prospective nonmarginal change in harvest. For sale, $V_h = P_w + V_a$ only for marginal change or if the nonmarginal change affects only the portion of harvest sold by the harvester (not the portion retained). In each case, the value of the end product alone is indicated by assuming the value of the activity (V_a) is zero. Subtraction of harvest costs from the gross values in the table would yield the net values. See Brown and Burch (1989) for a more detailed explanation of inferring economic value from subsistence users' market behavior.

To this point, we have focused on commercial market prices. However, a local price, or set of prices, may exist that is used among relatives, friends, and acquaintances which has little or no relationship to commercial markets. Usher (1976) suggests that local exchanges among rural Arctic residents are often performed at prices which depend on kinship or friendship between buyer and seller. The local price may not serve as a viable estimate of the marginal economic value of the good, if that price reflects a "gentleman's agreement" rather than an impersonal market.

The following five limitations of market observation for inferring the value of subsistence harvest are important. (1) Commercial markets for many products, especially wildlife species, are often lacking, and subsistence laws sometimes limit participation by harvesters in markets even where they exist (e.g., in Alaska, see Brown and Burch 1989). (2) Commercial sale may be difficult to distinguish from customary trade, which may occur at "friendly" prices that reflect the relationship between the parties to the exchange. (3) Market observation can potentially provide good estimates of marginal product value, but rarely of the value of the entire amount of the good harvested and consumed. The value of the entire good is reflected by the demand curve over the full quantity used, and this demand curve is not observable directly. (4) Computation of net value requires estimation of the harvester's cost of production, to be subtracted from the gross value. Few studies have estimated subsistence user's harvest costs. Cost estimation is usually complicated by the existence of joint costs spread over harvest of several products. (Cost estimation is a problem for all four valuation methods described herein.) (5) The method ignores the value of the harvest activity. The activity value may be minimal, especially at the margin, for a product harvested in abundance, such as fuel wood or a common fish species, but is not necessarily so. It is less likely to be low for products not harvested in large numbers, and for products that play a role in longstanding traditions.

Alternative Cost Method

In the absence of a viable market for forest products, the gross value of a loss of harvest could be estimated as the minimum cost of replacing the lost harvest, and the net value could then be estimated as this replacement cost minus the now avoided cost of providing the product (i.e., new cost minus old cost). Assuming a substitute exists and is purchased competitively, its price indicates what it would cost the rural resident if supply of the product at issue were constrained.

Users may or may not be consuming a forest product such that their marginal WTP for it is as great as the cost of the least expensive commercially available substitute. The similarity of marginal WTP and substitute cost is an empirical question, the answer to which may differ by location and time depending on the availability and cost of the full range of substitutes, but the substitute cost is likely to be considerably greater than the subsistence user's WTP at the margin. For example, assume the cost of the substitute is P_3 in Figure 1, and that the harvester is consuming at Q_1 where his demand (D_h) equals his harvest cost (S_a). The alternative cost method would estimate the gross value of the marginal wildlife unit as P_3, although the harvester's marginal WTP for harvest is only P_1 and for the product is only P_2.

In cases where the substitute price is greater than marginal WTP of the user, the appropriateness of the alternative cost approach rests on one of two propositions. The first is that society has a *responsibility* to provide the good or an acceptable substitute. This responsibility might be reasonable, for example, if the subsistence user were considered to have a *right* to the good, or if, for equity reasons, the government decided to assure access to the good. If provision of the good is taken as given, then the value to society of the harvest unit is as great as the cost of replacing it, since society would incur that cost in the event of a decision to limit availability of the good in question. The second proposition is that the compensation demanded perspective is appropriate, and that the harvester would not accept less than the alternative cost in compensation for a loss of the product. It has been argued elsewhere that the compensation demanded, or willingness to accept (WTA), perspective is appropriate for measuring a negative change in welfare -- that WTA is that sum necessary to leave the person as well off as he or she would have been without the change (Knetsch 1984). This case is strengthened where the persons suffering the welfare loss *perceive* that they have a right to the good being lost. If they do perceive they have a right to the good, then their personal loss is perhaps best measured in terms of WTA. However, if society has not accepted the responsibility to provide the substitute, and if there is no other justification for taking the WTA perspective, then the welfare change is more appropriately estimated as the WTP for the good.

Finding an appropriate substitute is likely to be difficult. Usher (1976) discusses three potential problems in relation to wildlife harvest. (1) Pound for pound, the nutrition provided by wildlife is typically greater than that provided from common substitutes such as beef. (2) Commercially produced substitutes such as beef may lack the taste characteristics of the wildlife product. (3) The activity of purchase at a store is far different from, and may bring far less satisfaction than hunting if the value of wildlife products to harvesters derives in part from the activity of obtaining the products (i.e., if D_a is positive over the relevant range in quantity).

Travel Cost Method

The travel cost method (Clawson and Knetsch 1966, Dwyer et al. 1977) values a site, such as a hunting area, by observing how much people are willing to pay to visit the site. The method is based on the reasonable assumption that people will make repeated trips to a site in a given season until the value of the last trip is just worth what they have to pay to get there. By measuring how often people visit the site from different distances, the value of all trips can be inferred, and the value of the site can be estimated. The value will include both activity and product value.

Application of the travel cost method to estimate the value of harvest of specific products by subsistence users faces at least three difficulties. (1) Travel cost analysis is best applied to estimate the value of a harvest site, rather than of a product. If harvest trips tend to jointly produce harvest of more than one product, isolating the value assigned to one product is arbitrary. (2) Application of the travel cost method requires that users of the site originate from locations at numerous different distances from the site. Typically, however, rural residents of only one or a few areas harvest at given site. (The degree to which use of modern backcountry transportation has altered this is unclear.) (3) In valuing wildlife products where the species' habitat covers a wide range, such as salmon or some big game species, and hunting or fishing occurs in many different areas, isolating specific sites as the focus of the valuation may be problematic.

Contingent Valuation Method

Contingent valuation employs carefully constructed questionnaires to elicit individual estimates of monetary value for some hypothetical change (Cummings et al. 1986, Mitchell and Carson 1989). Contingent valuation can potentially measure the value of marginal or nonmarginal changes, and estimate both activity and product values. The method can be used to elicit indications of WTP to obtain a positive change or to avoid a negative change, and potentially to elicit WTA to endure a negative change.

The flexibility to specify the resource change, payment or compensation vehicle, and other elements of the hypothetical situation makes contingent valuation an attractive valuation choice. It is the only method that can straightforwardly measure activity value and the value of large changes, such as loss of access to a forest product. However, care must be exercised when the focus is a large change such as loss of access. If we ask more traditional subsistence users in a contingent valuation survey what they are willing to pay to maintain resource use, we are asking to a certain extent what their way of life is worth to them. Indeed, access might be considered a weak complement to that way of life such that, if the change at issue is removal of resource access, the value of the access includes the value of the way of life. But can the typical respondent deal with such monumental issues in the context of a survey question about a specific resource change?

Furthermore, to the extent that access is integral to maintenance of the way of life, the WTP of a cash-poor rural resident may introduce such a serious equity question that the monetary estimate becomes of only academic interest. However, WTP may not be the appropriate perspective for valuing subsistence users right of access; their loss may be more appropriately measured in terms of WTA.

The problem then becomes one of designing an appropriate WTA valuation instrument. Two nearly contrary concerns arise. On the one hand, given the special place of natural resources in many subsistence users' way of life, it may not be possible to design a contingent valuation survey without incentives to overstate WTA for resource access. A significant proportion of infinite bids would be likely, and it would be difficult to distinguish between those representing protests at the idea of valuing such a good monetarily and those representing legitimate expressions of exceedingly high value. On the other hand, some respondents may state a finite WTA, when in fact they would not consider selling the good at any price if they believed they could avoid the sale. Their bid may reflect what they believe is the best deal they are likely to get, because past experience had shown that they had little power to forestall change proposed by the political power structure.

Estimates of value obtained using contingent valuation would potentially suffer from three additional problems, when applied to estimate values of subsistence harvesters. (1) Respondents who are unaccustomed to thinking about the monetary value of the good in question may have difficulty.[5] Research is lacking on the validity of using contingent valuation with populations who are less accustomed than the average American citizen to markets and monetary valuation. (2) Subsistence harvesters tend to live in rural villages. If a prospective change will affect only one village, the entire population of respondents may be insufficient to enable reliable estimation of monetary value. Furthermore, potential respondents are likely to discuss the survey among themselves before all have been contacted by the interviewers, possibly biasing the later responses. Indeed, collective decision making is traditional among some subsistence groups, and respondents may insist that discussion among themselves is necessary before they can or will comply. (3) Mistrust of resource management agencies and a reluctance to divulge information may affect survey responses.

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[5] An alternative to using money directly would be to solicit responses about nonmarket goods in terms of other goods that have relatively well established prices, such as lumber or furs have in many locations.

CONCLUSIONS

Where markets exist for products harvested by subsistence users, and these users are price takers and can participate in such markets without substantial transaction costs, market prices can provide indications of the economic value of the product. However, such prices ignore the value of the harvest activity, and are inadequate for valuing the total value of harvest or the right to harvest the product.

Where appropriate substitutes exist, and society has either assumed the responsibility to replace lost harvest, or accepted a compensation demanded valuation perspective, the alternative cost approach is attractive because of the relatively low level of effort required. But suitable, competitively-sold substitutes are not always available, and the approach also ignores the value of the activity.

Contingent valuation is potentially well suited to estimate both product and activity value, and to estimate values of large nonmarginal changes, but the method may be difficult to apply with populations of subsistence users, and the ability to focus on large losses may not easily be realized.

The clear distinction between efficiency and equity in neoclassical economics places a considerable burden on decision makers. They must realize that willingness to pay is conditioned on ability to pay, which may be generally lower among people participating in a subsistence way of life than among nonparticipants. Estimating the value of resources in willingness-to-pay terms may therefore put participants at a disadvantage relative to nonparticipants, allowing nonparticipants, such as persons with full-time wage-earning jobs, to bid resources away from subsistence users.

Economic valuation methods clearly have their limitations, especially in measuring the value of large nonmarginal losses affecting a people's way of life. But, we cannot expect more of economics than the theory and methods allow. Economic valuation can provide useful insights, and, as long as its limitations are recognized, contribute to informed decision making. To ignore economic valuation in major policy decisions affecting resource allocation might be just as serious an error as focusing solely on economic efficiency in such decisions.

LITERATURE CITED

Brown, T.C. 1984. The concept of value in resource allocation. *Land Economics*, vol. 60, no. 3, pp. 231-246.

Brown, T.C. and Burch, E.S., Jr. 1989. Estimating the economic value of subsistence harvest of wildlife in Alaska. Paper presented at the Alaska Wildlife Valuation Workshop, Anchorage, September 1989, 68 p. plus figures.

Clawson, M. and Knetsch, J.L. 1966. Economics of outdoor recreation. John Hopkins University Press, Baltimore, MD, 328 p.

Cummings, R.G., Brookshire, D.S. and Schulze, W.D., eds. 1986. Valuing environmental goods: An assessment of the contingent valuation method. Rowman and Allanheld, Totowa, NJ, 270 p.

Dalton, G. 1971. Economic anthropology and development: Essays on tribal and peasant economies. Basic Books, New York, NY, 386 p.

Dwyer, J.F., Kelly, J.R. and Bowes, M.D. 1977. Improved procedures for valuation of the contribution of recreation to national economic development. Research Report No. 128, Water Resources Center, University of Illinois, Urbana, 218 p.

Knetsch, J.L. 1984. Legal rules and the basis for evaluating economic losses. *International Review of Law and Economics*, vol. 4, pp. 5-13.

Krutilla, J.V. and Fisher, A.C. 1975. The economics of natural environments: Studies in the valuation of noncommodity and amenity resources. John Hopkins University Press, Baltimore, MD, 292 p.

Mitchell, R.C. and Carson, R.T. 1989. Using surveys to value public goods: The contingent valuation method. Resources for the Future, Washington, D.C., 463 p.

Polanyi, K. 1944. The great transformation. Rinehart, New York, NY, 315 p.

Sharif, M. 1986. The concept and measurement of subsistence: A survey of the literature. *World Development*, vol. 14, no. 5, pp. 555-577.

Usher, P.J. 1976. Evaluating country food in the northern native economy. *Arctic*, vol. 29, no. 2, pp. 105-120.

15 January 1990

MULTIFUNCTIONAL VALUATION OF FOREST PRODUCTS: THE RPA EXPERIENCE

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INTRODUCTION

The Forest Service manages about 87 million hectares of forest and rangeland, which provide a variety of commodity and noncommodity outputs: timber, forage, minerals, recreation, water, and fish and wildlife. An increasing United States population has resulted in increasing demands for forest outputs over time. The Forest Service is required by law to manage for all the multiple resource values on the National Forests and Grasslands. Managing the resource base to satisfy the varied and sometimes conflicting resource demands can be a challenging balancing act.

Resource management to maintain the long-term productivity of forest and rangeland resources requires long-term management strategies. Unfortunately, long-term planning is often at odds with the short-term realities of Congressional funding and policy-making. In recognition of this potential problem, Congress passed the Forest and Rangeland Renewable Resource Planning Act of 1974 (RPA). The RPA requires the Secretary of Agriculture to periodically prepare three documents: 1) an assessment of the nation's renewable resources at 10 year intervals, 2) a renewable resource program for the Forest Service on a 5 year cycle, and 3) an annual report of Forest Service accomplishments of the previous year. The second document, the Forest Service Program, is intended to guide long-term management of the National Forests and Grasslands and provide long-term direction for programs in research and state and private forestry (Haught, 1984). The Program is a primary vehicle for explicitly considering the balance among resource on Forest Service lands. Part of that process involves estimating forest product values for the economic analysis.

THE RPA PROGRAM PROCESS

The starting point for a Forest Service Program is the development of alternative management scenarios, or strategies, that describe a range of resource mixes. For example, in developing the 1990 RPA Program, five strategies were developed and evaluated.

Economic analysis is part of the evaluation process, which requires valuation of the resource outputs from the strategies. Because of data limitations, the economic analysis is only performed on the National Forest System portion of the Program. Therefore, the following discussion is relevant only to valuing products from the National Forests and Grasslands.

Economic Analysis in the RPA Program

Economic implications of the proposed strategies are only one of many factors used in evaluating the strategies. Two types of economic analysis were used to evaluate the economic impacts of proposed strategies for the 1990 Program. First, the impacts of the strategies on employment and income were estimated using an input-output model developed by the Forest Service. Second, the economic efficiency of each strategy was evaluated by comparing the benefits and costs of each strategy. Valuation of forest outputs was required for the efficiency analysis.

The Program strategies describe a stream of forest outputs over a 50-year period. Benefits and costs associated with the level of outputs were estimated for each strategy. A present net value approach was taken to reduce the stream of benefits and costs to a single number. Forest Service Regional offices provided estimates of the costs of producing the output levels associated with each strategy.

Resource Values for the RPA Program

Values could not be estimated for all forest resource outputs. Values were estimated for five categories of outputs: timber harvest, mineral production, forage consumption, recreation use (including fish and wildlife recreation), and water production.

Resource outputs have different values at different stages in the production process. The first decision in the valuation process was to value all forest outputs "on-forest." The costs in the present net value analysis only include costs incurred by the Forest Service, so only benefits generated from Forest Service activites were included. For example, timber was valued on the stump - at the point where Forest Service personnel prepare the timber for harvest. The value added by harvesting and hauling was excluded because the costs at that stage fall on the timber harvester. Activities such as recreation are valued at the point of use on the forest; the cost of complementary goods and services are excluded. In the case of recreation activities taking place on sites developed by private contractors (such as developed ski sites), the recreation values were net of private investment costs, since those costs do not fall on the Forest Service.

There is no unique "on-forest" value for the resource outputs. The appropriate "value" of a product depends on the objective of the economic evaluation. Three possible objectives were considered in designing the analysis for the Program. The first objective was a balanced federal budget, in which case the appropriate value is the amount returned to the treasury per unit of output. The second objective was an efficient private market solution, in which case value should be derived from market information. The third objective was an efficient social solution, in which case the value should be derived from consumer surplus measures (Peterson, Brown, and Rosenthal, 1987). All three objectives were considered relevant for planning purposes. Therefore, three values had to be derived for each of the outputs.

Accounting Stances for the Economic Analysis

Three "accounting stances" were defined to relate to each of the three objectives. The first stance, "existing fees," estimates returns to the Federal Treasury. Under this stance, the output value is the fee per unit of output paid by the user. These values are mandated by law and often have no relation to market prices. Currently, fees are only charged for timber harvest, extraction of some minerals, livestock grazing, and a limited number of recreation activities.

The second accounting stance is "market-clearing prices." This accounting stance is essentially a cash-flow approach to computing value, similar to the approach that would be used by private industry to evaluate an investment proposal. The values were derived primarily from existing market information.

The third accounting stance is "market-clearing price plus consumer surplus." This stance uses values that estimate total social benefits, a stance that is usually unique to government planning. Consumer surplus values are the basis of most of the values derived for this stance. In most cases, consumer surplus measures were converted to average values so they could be applied per unit of output.

Values for the existing fees accounting stance were simply taken from existing schedules of charges on the National Forests and Grasslands. Deriving resource values for the other two accounting stances for each resource output was more challenging. Market data was readily available for comodity outputs, while consumer surplus values were more readily available for noncommodity outputs.

1990 RPA RESOURCE VALUES

The procedures for estimating market-clearing prices and market-clearing price plus consumer surplus prices for each resource output is described below. These descriptions illustrate the variation in data availability and reliability of the estimates.

Market-Clearing Prices

Market-clearing prices for timber were readily available. Historical data on competitive bids for National Forest timber were used to estimate a set of baseline timber prices by product category: softwood sawtimber, hardwood sawtimber, softwood roundwood, and hardwood roundwood. A five-year average of bid prices were used to smooth out market variations.

Market-clearing prices for forage were based on a 1983 market value appraisal jointly conducted by the Forest Service and Bureau of Land Management. The study derived an appraised market value for grazing on public lands. Average lease rates negotiated for grazing on private lands were used as a basis, with a downward adjustment to reflect differences in the terms and conditions generally attached to Federal permits as compared to private leases.

Market-clearing prices were estimated for 13 minerals: oil, natural gas, coal, geothermal, lead, phosphate, copper, gold, silver, uranium, molybdenum, sand and gravel, and crushed stone. This list is not exhaustive, but it covers most of the production of mineral commodities from National Forests and Grasslands. The prices were calculated by taking the market commodity price and subtracting all the operator's estimated costs required to extract and mill the material.

Market-clearing prices for water were only estimated for consumptive and withdrawal uses of water. No value was estimated for instream uses or water quality because of lack of data. Market-clearing prices were estimated by Region for four water uses: agricultural, municipal, industrial, and thermoelectric. Ideally, the values should be for raw water rather than delivered, since that is the appropriate "on-forest" value. However, delivered water values were used when they were the only available values. The availability of data varied by Region, especially since the development of water markets varies by Region. Values across the four water uses were averaged into a regional water value, based on the proportion of regional use in the four categories.

Market-clearing prices were estimated for 15 recreation activities: camping, picnicking, swimming, mechanized travel, viewing scenery, hiking, horseback riding, water travel, winter sports, resorts, wilderness, hunting, fishing, nonconsumptive wildlife recreation, and all other recreation activities. Although private markets for recreation activities are expanding, there was not sufficient market evidence to estimate prices. As a result, market prices were derived by reducing the market-clearing price plus consumer surplus prices by a fixed proportion that varied by activity.

Market-Clearing Price plus Consumer Surplus Prices

Market-clearing price plus consumer surplus prices for timber were derived from the market-clearing prices. If a demand curve is assumed to be linear, the average market-clearing price plus consumer surplus price satisfactory. The marginal value product is greater than the market-clearing price, but is conceptually different from a consumer surplus estimate. A possible future approach for forage values is to explore the availability of forage demand elasticity estimates for adjustment of market-clearing prices.

No market-clearing price plus consumer surplus prices were estimated for water. No solution to this problem is readily apparent, given the difficulties with evaluating water markets.

The recreation prices were the only ones that were based on actual estimates of consumer surplus. The main shortcoming of these values is the reliance on aggregating a set of diverse studies that often use different valuation techniques and value different types of experiences, even within the same activity group. The methodological adjustments eliminate some of the potential differences in results from varying measurement techniques. However, the studies are also likely to differ in the type or quality of recreation experience. The averaging of values from studies with different types of experience also averages across experience types. However, unless the values are correctly proportioned to reflect the availability of different types of experiences on Forest Service lands, the average value is not representative of the value of recreation opportunities on those lands. For example, assume 10 studies are available for the value of big game hunting. Of these studies, 5 were studies of trophy hunting experiences, while 5 were for lesser quality hunting experiences. Assume also that the proportion of opportunities for trophy hunting on the National Forest lands is 15 percent of all big game hunting. A simple average of the 10 big game hunting studies will weight the trophy hunting values equally with the other studies, resulting in an average value not truly representative of available recreation opportunities. Studies used in the estimation of the recreation values should be evaluated for possible biases of this sort. In addition, the possibility of increasing the use of national data sets to estimate recreation values from a consistent source of data should be explored.

Comparability of Resource Values

The market-clearing price and market-clearing price plus consumer surplus accounting stances were developed partly in response to a concern that it was incorrect to use market prices for commodity resources and consumer surplus values for noncommodity resources in the same present net value calculation. As a result, separate values are estimated for each accounting stance to be used in the present net value calculation.

The benefits for each Program strategy are calculated by applying the resource values to total forest production in each of the 50 years. Applying the market-clearing price provides a measure of total "potential revenue," the amount that would be generated if all outputs were traded in competitive markets. Applying the market-clearing price plus consumer surplus value provides a measure of the total social benefits generated by the forest outputs.

CONCLUSIONS

Valuation of forest products is a difficult process. The process is further complicated when different types of values must be estimated, and they must be specific to National Forests and Grasslands. Additional work is needed for the market-clearing prices and market-clearing price plus consumer surplus prices for almost all resource outputs. There are continuing advances in valuation theory and application, and new sources of market information to draw upon for the next round of estimating RPA values.

The accounting stance approach to grouping resource values worked in the evaluation of program strategies because total production was valued. The economic analysis did not value incremental changes in resource production by comparing changes in cost to changes in output levels. If the incremental approach was taken, the accounting stance approach would not work. For incremental analysis, the relevant values depend on whether the changes in resource production affect resource prices. In such an analysis it is possible that marginal prices from competitive markets for some resources are appropriately mixed with consumer surplus values for other resources. This incremental approach is not used in the RPA Program, which limits the use of the resource values for evaluating trade-offs between resources.

LITERATURE CITED

Haught, Adrian. 1984: Economic analyis of national land planning in the United States: Proceedings for economic value analysis of multiple-use forestry. International Organizations of Forestry Research Organizations.

Peterson, George, L., Thomas C. Brown, and Donald H. Rosenthal. 1987: An improved framework for estimating RPA values. Forest Service General Technical Report RM-138. Rocky Mountain Range and Experiment Station, Fort Collins, Colorado.

Sorg, Cindy F. and John B. Loomis. 1984: Empirical estimates of amenity forest values: a comparative review. Forest Service General Technical Report RM-107. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colordo.

ECONOMIC EVALUATION OF GYPSY MOTH DAMAGE IN THE UNITED STATES OF AMERICA

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SUMMARY

The positive, negative, or neutral ecological changes resulting from gypsy moth defoliation and mortality following outbreaks together with economic values and the impact on management objectives are discussed. Both timber and non-timber values are considered. Economic analyses can be used to help make decisions on pest management actions.

Keywords: *Lymantria dispar* L., non-timber values, timber values, pest management, economic impacts

INTRODUCTION

Since introduction into North America in 1869, the gypsy moth, *Lymantria dispar* L., has become established as one of the most visible forest pests in the United States. Millions of dollars have been spent on gypsy moth eradication, control, and research. Defoliation and mortality caused by gypsy moth affect the productivity, uses, and values of forest resources in many ways. The net effects can usually be measured in biological and ecological terms, but expressing the outcomes in socioeconomic terms is not an easy task. Economic evaluation requires the placement of a value on the damage caused by the insect. These values are used to determine how the insect affects management objectives and public perceptions, and benefits can be compared with costs to help make decisions on pest management practices. Not all of the ecological effects of gypsy moth outbreaks are negative; so the positive values offset some of the negative values. Net benefits might result from an outbreak in some forest stands, depending upon management objectives. The purpose of this paper is to discuss the ecological effects of gypsy moth outbreaks and provide economic evaluation. Several different types of economic analyses have been used in gypsy moth evaluation and examples are presented.

ECOLOGICAL AND ECONOMIC IMPACTS

The ecological information available varies widely by resource type. Tree and forest stand information is plentiful, and recent research is directed toward information on other resources. There is much economic information on timber values also. Pest management suffers from the same difficulty in valuation of non-timber resources as multiple-use forest management.

Aesthetics and Recreation

Dramatic photographs of 30-km long, defoliated ridges have epitomized gypsy moth outbreaks of the 1970's and 1980's. Temporary loss of aesthetics (unsightly appearance of defoliated trees and stands) has been consistently one of the highest ranking negative effects of gypsy moth defoliation (Brown and Sheals 1944; Forbush and Fernald 1896; Goebl 1987; Marler and McCrea 1977; Moeller et al. 1977; Turner 1969). Nuisance caused by the presence of insects, frass, and premature leaf litter ranks second. Anyone who has tried to have a picnic in the middle of thousands of crawling larvae knows how negative this effect can be. Other negative effects are: presence and hazard of dead trees, allergic reactions to larval hairs, and loss of shade, but none of these received very high importance rankings relative to aesthetics and nuisance. There have been no reported positive effects on aesthetics and recreation with the exception of increased hunting benefits. The lower ranked effects may have little economic impact. The work on aesthetics has placed more emphasis on defoliation than on mortality. Currently, Brock and Hollenhorst of West Virginia University are examining the effect of tree mortality on aesthetic preferences using the Scenic Beauty Estimator technique. The costs of hazard reduction due to dead trees in campgrounds, picnic areas, and other concentrated recreation areas may be underestimated because damage surveys are often conducted before all the mortality has occurred.

Quantification of values for aesthetic and recreational losses has used person-days of recreation loss, control costs, and financial losses due to infestation. These costs do not reflect all of the impacts. For example, Goebl (1987) reported that the quality of experience was reduced for 68 percent of the recreation users of the Allegheny National Forest. Recreational use on the Forest in the summer of 1986 was reduced about 20 percent. Recreational loss averaged 16 person-days in 4 percent of the commercial campgrounds, 36,660 person-days in 25 percent of public recreation areas, and 240 person-days in 12 percent of quasi-public recreation areas surveyed (Moeller et al. 1977). The low number of recreation areas reporting losses is indicative of the high level of control. Average control costs, in addition to public funded control programs, for commercial campgrounds were $269 per outbreak per campground and for quasi-public recreational areas $440 per outbreak per area (Moeller et al. 1977). Average financial loss (defined as capital cost reduction in property value, increase in maintenance costs, and loss of revenue) due to a gypsy moth infestation was $152 per outbreak per campground for 22 commercial campgrounds and $607 per outbreak per area for 35 quasi-public recreation areas (Moeller et al. 1977).

Current work at West Virginia University utilizes information on willingness to pay, likelihood of visiting, length of stay, expenditures, and likelihood of return visits to analyze the effects of gypsy moth damage on aesthetics and recreation/tourism behaviors. It is necessary and usually economically feasible to control gypsy moth populations in high use recreation areas to prevent loss of quality of recreational experiences and loss of revenue. However, more rigorous economic analysis is required to determine the feasibility of treating areas of dispersed recreation (hiking, cross-country skiing, hunting, fishing, etc.).

Forested Residential

Gypsy moth effects on forested residential areas are very similar to aesthetic and recreation effects; the two major negative effects are nuisance followed closely by loss of shade and unsightly appearance of defoliated trees (Marler and McCrea 1977; Moeller et al. 1977). Marler and McCrea (1977) reported that the two largest effects on residential owners was loss of enjoyment of backyard recreation and loss of enjoyment of natural beauty. A distant third place was loss of property value followed by increased maintenance costs. More than half of the homeowners interviewed reported a loss in backyard recreation with average losses ranging from 50 to 158 person-days. Homeowners reported losses of 108 to 138 person-days of backyard recreational use (Moeller et al. 1977). Control costs averaged $62 per homesite per outbreak beyond cost of public control program for homeowners participating in them and $146 per homesite per outbreak for homeowners using commercial control programs. Total financial losses for the two groups of homeowners were $76 per homesite per outbreak for those in public control programs and $292 per homesite per outbreak for those using commercial control programs. Costs of removing hazardous dead trees were not included in these results, but would have increased financial losses considerably. An economic analysis of hazard removal would probably show that it is better to control gypsy moth populations than to remove high hazard dead trees several years later.

One area of potential neutral or positive effect is that of change in property values due to dead trees. One study shows that there is an optimal number of trees that contribute to property value (Payne et al. 1973). If the property has fewer than optimal, then mortality will reduce property value. Conversely if tree count is more than the optimum and gypsy moth reduces the number of trees down to the optimum, mortality will increase property value. Finally, if tree numbers remain close to the optimum, there will be little or no effect.

Wildlife and Fish Habitat

Information on gypsy moth effects on wildlife and fish is lacking. However, this has not prevented people from stating that gypsy moth is responsible for both decreases and increases in various wildlife species. Because wildlife populations are regulated by many factors, it would be difficult to show that gypsy moth is responsible for changes in populations. An alternative approach discusses the quality of habitat and how gypsy moth outbreaks can alter it. Some species like conditions that other species do not. A single change in habitat may be positive for one wildlife species, negative for another species, and neutral for a third species, all at the same time. Also, change in habitat does not necessarily result in a change in wildlife populations, but it can enhance the potential for a change. If a habitat feature is not limiting, then increasing quantity of that habitat feature will not increase populations. Only a change in the limiting features will make an immediate difference, positive or negative. If a negative habitat change occurs due to gypsy moth, a drastic drop in the wildlife species' population could occur if this feature becomes the limiting factor.

Potential habitat changes that can occur include: higher water temperatures; lower water quality; more woody debris in streams and litter; less hard mast production; more soft mast production; more snags, den and cavity trees; more understory vegetation and vertical stratification; less protective cover; changed microclimate; more patchiness; and more insect availability. Many wildlife biologists consider the increase in snags and den trees accompanied by increased understory and midstory vegetation to be very beneficial to many wildlife species. These habitat features were absent or present in small amounts in many of our eastern hardwood forests. Loss of cover due to defoliation is an important negative feature for many nesting birds. Perhaps the most serious negative effect is loss of mast production. Defoliation can result in several consecutive years of complete mast failure, a situation uncommon in nature and one that few wildlife adapt to (Liscinsky 1984; Palmer 1988). In the long term, loss of hard mast is partially compensated by the increase in soft mast production by understory vegetation. Increases in stream water temperatures and changes in water quality may have negative effects on fish habitat, especially for cold water species, but no work has been done in this area. Studies on the effects of gypsy moth on breeding birds have shown few consistent effects either positive or negative on bird densities despite drastic changes in habitat (Cooper et al. 1987, DeGraaf 1987, DeGraaf and Holland 1978).

There is even less economic data available for wildlife and fish habitat effects than there is for ecological information. Laws governing endangered and threatened species may dictate control (or lack of control) actions despite the economic feasibility. It is critical to know the wildlife management objectives for the area. This knowledge will help determine which species are important, what the consequences of control actions will be, and allow an economic analysis to determine the feasibility of undertaking control actions. For hunting and fishing, many of the same economic measures that are used for other recreational activities can be used (willingness to pay, likelihood of returning, expenditures, etc.). For non-game species or objectives that call for maximizing diversity, methods are virtually non-existent.

Water Yield and Quality

Gypsy moth defoliation causes an increase in water yield (Corbett and Lynch 1987). In one study in New Jersey, the increase was 13.6 cm or 1,365 m^3/ha or a positive benefit for the City of Newark of $7.93 per ha (Corbett and Heilman 1975; White and Schneeberger 1981). Eighty percent of the increased yield occurred during the growing season. This increase will diminish over several years as the outbreak ends and new foliage replaces the foliage lost to tree mortality. However, since there is a high correlation between drought and outbreaks of defoliating insects (Mattson and Haack 1986), the increased yields generally come at a time when they are needed.

Water temperatures have not been measured in defoliation-influenced streams, but are not likely to rise by large amounts. In studies where all streamside vegetation was killed by herbicides, stream temperatures increased between 1 and 2°C mean maximum temperature (Corbett and Heilman 1975) and summer maximum temperature increased 3°C (Swift and Messer 1971). These increases would only affect cold water fish in streams that were marginal habitat. Water quality effects due to increased levels of nutrients in the ground or stream water have generally not been shown (Corbett and Lynch 1987), except one study showed an increase in stream nitrate-nitrogen levels (Swank et al. 1981). Corbett and Lynch (1987) showed large increases in fecal coliform and fecal streptococci levels in three pristine forest streams that were defoliated for 2 years. Bacteria levels increased during the defoliation period and then decreased in the fall. The bacteria were from nonhuman sources, presumably gypsy moth frass, and could pose a human health hazard for municipal water supplies. In 1981, numerous New England communities had to increase chlorination levels during gypsy moth defoliations. The economic impact of contaminated drinking water is an area that needs more study, both from an ecological and value perspective.

Fire Hazard

Heavy defoliation from gypsy moth increases fire danger. It exposes the litter and understory to direct sunlight, drying it out and maintaining more favorable fire conditions later into the summer than normal. Litter levels are also increased in the summer due to leaf fragments. After mortality has occurred, small woody and coarse woody fuels increase. This increase in fire hazard can be calculated using a formula presented in White and Schneeberger (1981). The equation is based on the National Fire Danger Rating system and computes costs for fire prevention, fire treatment, and fire damage for defoliated areas and undefoliated areas to arrive at the increased cost due to defoliation. While the methodology exists, no one has measured differences in fuels and calculated the increased hazard. Due to the infrequent fires during the growing season in eastern hardwood forests, I suspect that increased fire hazard would only be significant from long-term increases in woody fuels following mortality and not from direct defoliation effects.

Current Timber Values

Timber is the one forest resource for which economic information about the effects of gypsy moth abounds. Most timber effects could be classed as negative, but some of the effects can be positive or at least neutral. Current timber effects can be categorized as mortality, increment loss, quality loss, and changes in stand composition and stocking. Data on these changes date as far back as 1911. Campbell and Sloan (1977) reported that mortality on study plots between 1911 and 1921 was 46 percent and in the oaks was 60 percent. They did not try to develop an overall economic value. Perry (1955) used plot data and total defoliation figures to estimate total losses to mortality between 1933 and

1952 to be 6.5 million m^3 on 939,024 ha, worth $4,223,556. More recently, the Pennsylvania Bureau of Forestry has estimated total losses in Pennsylvania between 1969 and 1987 to be 180 million m^3 on 3 million ha, worth $219.6 million. Several types of economic analyses have been applied to timber losses; one involves straightforward current value loss similar to the above figures, another projects current losses into the future using net present value and compound interest, and a third uses the rate of value change (Gansner and Herrick 1982, 1987; McCay and White 1973).

Salvage and utilization of dead timber can reduce the economic losses of mortality. Unfortunately, the value of trees for veneer disappears as soon as they die and dead sawtimber trees lose 10 to 15 percent of their sawlog value per year after death (Donley and Feicht 1985). Placing large amounts of salvage on the market in a short time period can further depress prices as more volume comes up for sale than the mills can handle. This situation can also result in many areas going unsalvaged for lack of a market. Utilization of dead trees for sawtimber is feasible for the first 2 to 3 years after death, but it is preferable to salvage within the first year (Labosky 1987). Dead trees are usable for pulpwood for at least 5 years after death and perhaps even longer. Economic analyses of salvage, markets, and utilization for pulpwood has not been attempted.

Trees that survive defoliation suffer growth loss due to reduced leaf area and increased utilization of carbon reserves for refoliation. Losses usually average 40 to 60 percent of normal diameter growth (Baker 1941). Losses in volume growth depend on defoliation intensity and averaged 20 to 50 percent (Twery 1987). Few economic analyses of growth loss have been done; they can be done using stand growth models and stumpage values. Perry (1955) in the same 1933 to 1952 impact study estimated growth loss to be 4.2 million m^3 on 2.6 million ha, worth $2.4 million or approximately half of the value lost to mortality. Even less is known about the potential effect of growth loss on wood quality. If uneven growth and rings containing predominately large-vesselled springwood are considered low quality, then an additional economic loss would occur.

One area of possible neutral or positive benefits is in stand composition and stocking changes. Mortality shifts species composition away from oaks and toward other species producing a more resistant stand (Campbell and Sloan 1977; Herrick and Gansner 1987). An economic analysis of this shift has not been done, but it may very well be negative economically, because oaks are often more valuable than the other species that replace them. Because smaller, weaker trees are the first to die from defoliation, many stands receive a thinning from the gypsy moth-related mortality. At least one study found that stocking level changes resulted in fewer overstocked stands, the same number of fully stocked stands, and a slight increase in understocked and poorly stocked stands (Herrick and Gansner 1988). The negative part of this thinning is that the gypsy moth is marking the stand rather than the forester, and forest management opportunities for intermediate cuttings may be lost. While not an extensive analysis, Herrick and Gansner (1987, 1988) showed that many stands recovered to their original volume and value within 7 to 9 years.

Future Timber and Other Values

Values of future stands are related primarily to gypsy moth effects on regeneration. Because most eastern hardwood stands are regenerated naturally, any impact on the regeneration process will be costly to remedy. The major effects are shifts in species composition in new stands and loss of forest cover due to regeneration failure. Loss of oak seed production due to defoliation (Liscinsky 1984; Palmer 1988) and loss of seedlings and stump sprouts has reduced the proportion of oak in new stands (Allen and Bowersox 1989, Gottschalk 1988). This shift in species composition may affect future timber values due to less valuable species dominating, and wildlife habitat will change because less hard mast production is present. In some areas, defoliation and mortality coupled with heavy deer browsing has resulted in complete regeneration failures (Gottschalk 1988). In central Pennsylvania, areas have been dominated by herbaceous and shrubby vegetation for almost 20 years with no regeneration potential present. This loss of forest cover reduces all non-timber and timber values considerably due to the long delay in regeneration. Artificial reforestation of these sites will be expensive. Values need to be placed on these long-term impacts and run through simulation models to estimate the losses that result.

ECONOMICS OF PEST MANAGEMENT PRACTICES

Books have been written on the topics of pest management economics and forest management economics. My intent is to show a few examples of different types of economic analyses that have been applied to gypsy moth management and to point out some areas that need analysis.

Cost Plus Loss Basis

Herrick (1981) adapted the least-cost-plus-loss economic theory to determine how management costs of controlling gypsy moth populations should be balanced against the reduction of timber value impacts. The theory is in effect a willingness to pay on the part of the people affected by the impact in order to avoid the losses. The theory is fine for understanding the problem, but it is very difficult to develop the functions needed--a damage function, a cost function, an intensity function, and the proportion of the area treated--to develop a cost plus loss curve. The minimum value of this curve is the lowest cost plus loss and gives the optimum treatment level (land area) and optimum expenditure level (dollars). At this treatment level, the marginal damage equals the marginal pest management cost, so any other treatment level would cost more than the value saved. This analysis is used to allocate limited resources to treatment areas to maximize the value saved. While the example given only considers timber value, it could be modified to include other values.

Benefit-Cost Analysis

An analysis by Hicks et al. (1989) used actual timber volume losses (average loss of 29 percent or 40 m^3/ha) from 106 plots valued using stumpage prices to calculate a break-even benefit cost analysis for aerial spraying the stands to prevent timber value loss. The stands were assumed to be 60 years of age (a reasonable average for the region) and 20 years from the end of the rotation. Four situations were used; stumpage prices for West Virginia and Maryland and spray treatment frequencies of 5 year and 10 year intervals until the end of the rotation. All costs and benefits were discounted back to the present using 6 percent as the rate of return. The point where benefits and costs were equal was considered the break-even point. This value is the maximum amount a landowner could afford to pay for each spray treatment and still not lose money. Break-even costs for West Virginia stumpage rates were $53/ha for 5-year treatments and $93/ha for 10-year treatments. Maryland stumpage rates were $28/ha for 5-year treatments and $48/ha for 10-year treatments. The Maryland break-even costs were lower due to lower stumpage prices. Since average spray costs are in the $2 to $8/ha range, the benefit-cost ratio for all of the tested combinations ranges from 3.5 to 46.5.

Capital Protection Basis

One somewhat unusual approach to gypsy moth economic analysis is being used by a major forest products company. They use a "quick and dirty" analysis to determine if spraying a stand is feasible (Trew 1987). The cost of protecting the stand is divided by its stumpage value; i.e., $2/ha spray cost divided by $20/ha value would give 0.1 while $2/ha spray cost divided by a value of $80/ha would give 0.025. Thus, 10 percent of the first stand value must be saved by the treatment in order to break-even while in the second stand only 2.5 percent of the stand value needs to be saved. This approach is not much different from the previous example, just simpler to apply. The company also uses the same approach on what I call a capital protection basis. Since the mills need to keep producing in order for the company to make a profit, some forest stands are owned and held in reserve to guarantee wood supply for the mill in periods of need. Since these stands are insurance capital, they need to be protected. The same calculation is applied as above, but the result indicates that the company can afford to spray the first stand 10 times and the second 40 times before they have lost money on their insurance investment.

Nuisance Prevention

When people are confronted with their first gypsy moth outbreak, emotions usually are very intense. Prevention of nuisance becomes so important that no economic analysis is needed, treatment is acquired at any cost and in some situations when it is too late to do any good (i.e. after pupation has occurred). Unscrupulous practices and political demands for action by constituents have resulted in public treatment programs for nuisance prevention. Most of these programs require some cost sharing by the landowner or the local government. While these programs address many needs and issues, private treatments for nuisance prevention are still a major factor in many areas. As people's experience and tolerance of gypsy moth outbreaks increases, their willingness to pay for nuisance prevention decreases. Better information on people's values and attitudes toward gypsy moth and how they change with experience would be useful for development and management of public programs.

Public Versus Private Programs

What is the appropriate mix of publicly financed versus privately financed control programs? This is a difficult question--one which many states and local governments (as well as the federal government) have had to address. In most public programs, highest priority areas for treatment are forested residential areas that meet the eligibility guidelines set up for the program. Second (or tied for first) are public and private recreation areas. Publicly-owned forest and wildlife lands are often the last on the list to receive treatment using public funds. Because residential dwellers on forested land complain loudly to their elected officials, the officials respond. This is the way our political process works. Very few people complain about the public forest lands, so most politicians do not respond with money to protect them. However, an argument could be presented that public control funds should be used for programs on public lands and private money should be used (possibly with public coordination) to fund control on private lands. It is a matter of special concern that federal dollars ($6 to $10 million/year) are predominately spent on cost-sharing treatments on private lands, when many national forest hectares are not treated due to lack of funds. This policy issue is one that deserves some analysis on the appropriate roles of public and private funds. Use of decision models with good economic evaluations have the potential for answering some of these questions (Talerico et al. 1978; Valentine et al. 1976). Another question with similar policy implications, is that of using public money to fund suppression programs rather than prevention programs (integrated pest management (IPM) programs). While there are many advantages to IPM programs, they have a higher, annual cost (even when outbreaks are not present) and do not produce the political support that results in funding.

CONCLUSIONS

Impacts of the gypsy moth on forest resources are many and varied. Lack of knowledge about ecological effects and methods for valuing non-timber resources hamper efforts to do complete economic analyses on pest management practices. Gypsy moth control to protect these resources exceeds costs in many situations, but control is not always done due to limited funds. Questions about the optimal allocation of funds and other resources need to be answered. Integrated pest management programs need to be evaluated to determine if they are more cost-effective in the long run than squelching outbreaks with short run suppression.

Paper NE-275, 9 p.

Moeller, G.H., Marler, R.L., McCay, R.E. and White, W.B., 1977: Economic analysis of the gypsy moth problem in the Northeast III. Impacts on homeowners and managers of recreation areas. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Upper Darby PA, *Research Paper NE-360*, 9 p.

Palmer, W.L., 1988: Acorn production study. Pennsylvania Game Commission, Harrisburg PA, Unpublished report, March 1988, 5 p.

Payne, B.R., White, W.B., McCay, R.E. and McNichols, R.R., 1973: Economic analysis of the gypsy moth problem in the Northeast II. Applied to residential property. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Upper Darby PA, *Research Paper NE-285*, 6 p.

Perry, C.C., 1955: Gypsy moth appraisal program and proposed plan to prevent spread of the moths. U.S. Department of Agriculture, Washington, DC, *Technical Bulletin No. 1124*, 27 p.

Swank, W.T., Waide, J.B., Crossley, D.A. Jr., and Todd, R.L., 1981: Insect defoliation enhances nitrate export from forest ecosystems. *Oecologia*, vol. 51, pp. 297-299.

Swift, L.W., Jr. and Messer, J.B., 1971: Forest cuttings raise temperature of small streams in the southern Appalachians. *Journal of Soil and Water Conservation*, vol. 26, pp. 111-115.

Talerico, R.L., Newton, C.M., and Valentine, H.T., 1978: Pest-control decisions by decision-tree analysis. *Journal of Forestry*, vol. 76, pp. 16-19.

Trew, I.F., 1987: Developing a forest industry system for coping with gypsy moth. pp. 145-150, In: *Proceedings, coping with the gypsy moth in the new frontier*, Fosbroke, S. and Hicks, R.R., Jr., eds., August 4-6, 1987, Morgantown WV, West Virginia University Books, 153 p.

Turner, N., 1969: The gypsy moth in Connecticut. Connecticut Agricultural Experiment Station, New Haven CT, *Circular No. 231*, 8 p.

Twery, M.J., 1987: Changes in vertical distribution of xylem production in hardwoods defoliated by gypsy moth. New Haven CT, Yale University. *PhD. dissertation*, 96 p.

Valentine, H.T., Newton, C.M., and Talerico, R.L., 1976: Compatible systems and decision models for pest management. *Environmental Entomology*, vol. 5, pp. 891-900.

White, W.B. and Schneeberger, N.F., 1981: Chapter 7, Socioeconomic impacts, pp. 681-694 In: The gypsy moth: Research towards integrated pest management, Doane, C.C. and McManus, M.L., eds., U.S. Department of Agriculture, Washington, DC, *Technical Bulletin No. 1584*, 757 p.

January 9, 1990

ECONOMIC IMPACTS OF AIR POLLUTION DAMAGE TO U.S. FORESTS

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SUMMARY

This past decade has seen the emergence of concerns regarding forest decline possibly caused by acid rain or other air pollutants. In the U.S. attempts to estimate the economic impacts associated with forest decline have involved the application of forest sector models that combine economic and biological models. The economic impacts associated with prospective forest (growth) declines are concentrated in the Southern United States. On net, declines in forest growth lead to a reduction in overall welfare because of higher prices throughout the forest sector. Consumers are impacted more than producers but these impacts are slow to develop as they depend on changes in timber inventories.

Keywords: Forest Sector Models, Timber supply-demand models

INTRODUCTION

This past decade has seen the emergence of a number of concerns in the United States centered around the specter of forest decline possibly caused by acid rain or other air pollutants. These concerns have evoked public apprehension and led to large scale research programs such as the Forest Response Program--FRP (Schroeder and Kiester, 1989) and the National Acid Precipitation Assessment Program (NAPAP).[1] A major goal of this latter research program was to generate information useful in assessing the biologic and economic benefits of regulating specific pollutants.

Most of the research concern has focused on physical impacts and the need to integrate results from fundamentally different kinds of research. Of less interest has been the problem of how to measure prospective impacts in terms of economic or equity implications. Without this type of analysis, however, it will be difficult to convince "policy makers" of the need to shift policy. This is especially true for decisions that involve intergenerational equity.

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[1] The final NAPAP Assessment is due in 1990 (NAPAP 1988). This assessment includes the causes and effects of acidic deposition and related control and mitigation strategies.

The purpose of this paper is to describe both the method for valuing acidic deposition/air pollution effects on forests and some of the prospective economic impacts. This work was originally done for the 1990 NAPAP assessment.

METHODS USED IN THE U.S. FOR ESTIMATING ECONOMIC IMPACTS

The methods used for understanding and valuing the economic impacts of changes in forest productivity induced by acid deposition are largely drawn from those used by the U.S. Forest Service in the periodic assessments required by the Resources Planning Act (RPA).[2] Specifically, the primary method used is a model of the U.S. forest sector.[3] This model (the Timber Assessment Market Model [TAMM][4]) provides an integrated structure for considering the behavior of prices, consumption, and production in both stumpage and product markets. It includes a timber inventory projection system (ATLAS) that is an age class-yield function model. With TAMM, the simulation process for acidic deposition involves reducing the yield functions for various forest types by specified amounts. Reductions in the yield functions represent lower growth and, consequently, lower inventories. Lower inventories over time results in lower stumpage supplies, higher stumpage prices, and reduced product consumption and production. In the TAMM framework, the impact of reduced growth is not felt until inventories change enough to affect harvest levels since stumpage supply relationships are a function of timber inventory levels and prices. Further, the eventual impact depends on the markets for timber. Impacts in strong markets, such as those for southern pine, will show up faster than impacts in weaker markets.

The solution of TAMM represents a spatial equilibrium in the markets modeled for each year of the projection period. These solutions do not represent, nor can the basic market solution algorithm[5] be readily used to find, intertemporal production or consumption strategies that are in some sense optimal. The production, consumption, and price time paths are only estimates of outcomes of contemporaneous interactions in freely competitive markets. Details about the various input assumptions used in TAMM are described in the 1989 RPA Timber Assessment (USDA Forest Service in press).

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[2] More precisely The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 and its subsequent amendment by the National Forest Management Act (NFMA) of 1976.

[3] A forest sector model, in general, combines activities related to the use of wood: forest growth and harvest; the manufacture of pulp, paper, and solid wood products; and international trade and intermediate and final consumption of these products (Kallio et. al. 1987).

[4] The original model is described in Adams and Haynes (1980) and Haynes and Adams (1985).

TAMM is composed of ten major parts with exogenous inputs from four other models (Pulp, Trade, Fuelwood, and Land Area Change). Briefly, product demand, such as softwood lumber, is obtained by multiplying the ratio of product use per unit of activity (such as the amount of lumber used per house) times the number of units (such as the number of housing starts) and summing these results over all the various end uses for the product. The activity measures are exogenous and taken from long-term macro forecasts (i.e., WEFA 1987). The demand relationships are regionalized by accounting for differences in regional per capita consumption and the ratio of regional prices to national prices. Hardwood lumber is treated on the demand side in about the same end use detail as softwood lumber but the model is not spatial. Price is determined by simple supply and demand equality.

The product supply equations, in general, are a function of product prices, average variable production costs, and installed capacity. Average variable costs are composed of wood and nonwood elements that have been converted to a unit output basis by means of product recovery and productivity factors that reflect the current (or projected) technology of the industry. The role of capacity has been expanded in TAMM in that each product supply function has installed capacity as an independent variable. Capacity change is modeled as a function of anticipated changes in relative regional profitability or rate of return. Private sawtimber[6] supply is modeled for each region and owner as a function of stumpage price and growing stock timber inventory. Public sawtimber supplies are set by the allowable sales quantities determined by each agency. Finally the sawtimber demand functions are the sum of the roundwood equivalents of lumber, plywood, and log exports. Wood volumes used for OSB-waferboard output, pulp, miscellaneous products, and fuelwood are determined outside of TAMM and deducted from inventories but do not directly influence sawtimber stumpage prices. The pulp fiber requirements are input variables from a pulp model developed by Ince, Durbak, and Howard (in press). Trade and fuelwood projections are also input variables. The trade projections used in these simulations reflect a future where the U.S. remains a net importer of softwood forest products.

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[5] A revised reactive programming algorithm is used (Brooks and Kincaid 1987). Briefly, reactive programming is a method for solving continuous demand and supply function by successive adjustment of quantities produced and their distribution to demand regions so as to maximize producer profits net of transport costs in each supply region.

[6] Sawtimber stumpage includes live trees of commercial species containing at least one 4 meter sawlog or two noncontiguous 3 meter logs, and meeting regional specifications for freedom from defect. Softwood trees must be at least 23 centimeters dbh, and hardwood trees must be at least 28 centimeters dbh.

The remaining steps in the annual cycle of TAMM involve timber supply and an inventory projection system. The inventory projection system considers only the timber inventory located on private timberland that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Currently, areas qualifying as timberland have the capability of producing in excess of .6 cubic meters per hectare per year of industrial wood in natural stands and may be inaccessible and/or inoperable. Further, these models include only live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, these growing stock inventories includes only trees 13 centimeters dbh and larger.

The last component of TAMM is the timber inventory projection system (ATLAS) used to simulate timber inventories on all private timberland in the United States. This inventory projection model is an age-based, yield-table system that projects acres by detailed strata for periods consistent with the inventory stand-age classes. It evolved from earlier work by Beuter, Johnson, and Scheurman (1976) and Tedder, LaMont, and Kincaid (1987). In the model, the inventory is represented by acreage cells classified by region, ownership, management type, management intensity, and age class. In the South, the strata were also identified by site productivity class and stocking class. This study used 10-year age classes in all regions except the South where 5-year age classes were used.

In each simulation period, inventory change is the result of growth, area change, and timber harvest. Growth is the result of acres following upward sloping net yield functions that are calculated with approach-to-normal assumptions. Each cell in the starting inventory may have an independent yield function. A major attribute of the model is that it can simulate shifts in management intensities and consequent changes in yields based upon alternative assumptions about the future. The inventory model is not, in principle an even age model since it can simulate growth and removal processes across all age classes. ATLAS can also account for both partial harvests and commercial thinning. Volume can be removed at harvest from either the oldest age class or spread across several age classes. Final-harvested acres can be assumed to be regenerated in any management type or leave the timberland base entirely. Partial cutting affects a proportion of acres in a cell and the treated acres are assumed to back-down the cell growth function to a younger age class. Simulating the effects of growth declines involves shifting the yield functions downward.

Inputs to the inventory model include estimates of harvest, acreage shifts, and growth parameters. The levels of harvest are derived through interaction with TAMM. Area change information is supplied by a modified version of the Southern Area Model (SAM) (Alig 1985). Yield tables and approach-to-normal parameters were derived from timberland inventory plot data collected by the various USDA Forest Service Forest Inventory and Analysis Units and from previous studies (the inventory data inputs are summarized in Mills [1988]).

APPLICATION OF METHODS TO ESTIMATE ECONOMIC IMPACTS

deSteiguer and Pye (1988) recently summarized a survey of expert opinion estimating the damage caused by air pollutants to major U.S. forest ecosystems. Their purpose was to provide information to the economic assessments required as part of NAPAP. deSteiguer and Pye's findings can be summarized as follows in terms of periodic growth reductions:

	Hardwood Types	Softwood Types
	percent	
North	-5	-5
South	-5	-10

We implement these growth reductions in TAMM by lowering projected yields in all ages and stand types by the appropriate percentages for softwoods or hardwoods. Softwood growth reductions were assumed to be 10 percent in all regions. The yield shifts take place "immediately", ie., during the 1980's, so that all future stands have reduced volumes at harvest.

The impacts of these changes are presented as deviations from a base simulation of future market and resource conditions with no growth reductions. The simulation used is the base projection from the 1989 RPA Timber Assessment (USDA Forest Service in press). This projection portrays a future of continued increases in final product demand, somewhat slower increases in product and stumpage supply, and rising real product and stumpage prices. The projections also portray tight stumpage markets in the South, especially during the period 2000-2010. Stumpage markets in the North, especially for hardwoods, are expected to contain ample timber leading to modest price increases.

Growth, inventory, and harvest comparisons for two example regions in the Eastern U.S. are shown in Table 1.

Table 1. Growth, inventory, and harvest reductions

	Growth		Inventory		Harvest[1]	
	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood
			Percent			
Northeast						
2000	6	10	3	4	--	--
2020	6	9	5	8	--	--
2040	5	8	6	11	--	--
Southeast						
2000	6	9	3	9	--	6
2020	6	8	9	15	--	18
2040	8	8	10	21	--	21

[1] Sawtimber harvest only.

Projected growth falls quickly relative to the base simulation but not by the exact amounts (5 to 10 percent) of the yield function shifts. This results from shifts in the age classes, stand density and species composition of the inventory, relative to the base case.

Inventories change somewhat less rapidly and the impacts cumulate over time. By 2000, inventories for all species in the Northeast and hardwoods in the Southeast are only 3-4 percent less than in the base simulation. Softwood inventories in the Southeast, however, are 9 percent lower than the base. This reflects the strong markets for softwood stumpage in the Southeast and the close balance between harvest and growth, with reduced yields forcing harvest into younger age classes. Hardwood inventories decline by 2040 to 6 percent less in the Northeast and 10 percent less in the Southeast.

Changes in harvest are a reflection of the market model. The reductions in inventories in the North for both softwoods and hardwoods are relatively small and insufficient to stimulate changes in sawtimber harvest. In the Southeast, there are changes in both softwoods and hardwoods but sawtimber harvest impacts are only significant for softwoods. Softwood sawtimber harvest drops 6 percent by 2000 and 21 percent by 2040. Smaller drops in the near term reflect continued competitiveness of Southern products despite cost increases. In the longer term, high harvests in earlier years force inventory down and prices up sufficiently to constrict the region's market share.

Market impacts vary between species, regions, product and stumpage markets, and over time (Table 2).

Table 2. Economic impacts associated with growth reductions

	Stumpage Prices[1]			Lumber Prices	
	Hardwood	Softwood		Hardwood	Softwood
	All Regions	Northeast	Southeast		
			Percent		
2000	2	8	31	11	3
2020	3	23	27	6	13
2040	3	31	51	2	10

[1] Sawtimber harvest only.

Impacts in the near term, except for softwoods in the Southeast are modest. Stumpage price increases in the Southeast are significant. They rise rapidly in the near term as slow downward capacity adjustment (modeled as a function of profitability) lead to tight stumpage markets. Product prices rise and, in the case of softwood lumber, reduce U.S. consumption by 1 percent in 2000 and nearly 3 percent by 2040. The relationship between lumber and stumpage prices varies over time because of interregional adjustments in supply. U.S. lumber imports from Canada are 4 percent higher by 2000 and 38 percent higher by 2040. In general, production expands in Canada and slightly in western regions to offset reductions in Eastern regions.

The impacts for the Northeast and Southeast are shared by the Northcentral and Southcentral regions. The biological and economic impacts associated with growth declines differ. The biological impacts, other than for growth, are slow to develop. Reduced growth rates eventually lower timber inventories and harvests. Economic impacts are based on the harvest declines. The most severe economic impacts are in the South and, in particular, the Southeast where expected declines in softwood inventories in the base case are further aggravated by the assumed declines in growth. Economic impacts for both the North and for hardwoods, in general, are more modest.

Another way to gage economic impacts is to look at which groups (consumers, producers, and stumpage owners) gain or lose because of growth reductions associated with acidic deposition. Sample impacts are shown in Table 3.

Table 3. Annual estimates of changes in economic welfare for lumber and plywood producers and consumers.

	Consumer Surplus	Producer Surplus	Southeast Stumpage Owners Revenues[1]
		Billions 1988 dollars	
2000	-1.2	-.30	.03
2040	-7.2	-1.80	.06

[1] Computed as the difference in stumpage price per thousand board feet times harvest.

As a group, consumers are the most affected. Changes in consumer expenditures for softwood lumber (table 3) average 15 1988 dollars per household by 2040. In the near term (during the next two decades) potential consumer impacts are partially reduced by increased production in other regions including Canada[7]. By 2020, the opportunities for this offsetting production are exhausted increasing total impacts. Producers lose revenue as stumpage prices increase in affected regions. In the South, these losses are greatest in the next decade but fall after 2000 as producers reduce installed lumber capacity in response to lower harvest levels and higher stumpage prices. One interesting note is that reduced growth leads to increased plywood profits and production levels in the Southeast. As less timber becomes available, there is a shift from lumber to plywood production in the Southeast resulting from the availability of alternative sources for lumber relative to those for plywood.

Least affected are stumpage owners who, in spite of lower harvest levels (because of reduced timber inventories, in the long-run see increases in revenues derived from the sale of sawtimber. These results are due, in large part, to the inelastic nature of the demand for stumpage.

CONCLUSIONS

Forest sector models (such as TAMM) provide a means to place the issue of growth reductions (regardless of source) in perspective. They help show the relationship between biological and economic impacts, between species and regions, and the temporal dimension to the impacts. These models can also show the impacts of changes in the forest sector in terms of changes in the economic welfare of producers and consumers and on the real wealth of timber producers. On net, sample gain and loss comparisons suggest a reduction in overall welfare because of higher prices throughout the forest sector that accompany growth reductions.

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[7] This ignores the impact of any reductions in forest growth in Canada on Canadian lumber production.

LITERATURE CITED

Adams, D.M. and Haynes, R.W. The 1980 Softwood Timber Assessment Market Model:structure, projections, and policy simulations. Forest Sci., Monograph No. 22, 62 pp.

Alig, R.J. 1985. Modeling area changes in forest ownerships and cover types in the Southeast. USDA Forest Service Research Paper RM-260. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO. 18p.

Beuter, J.N.; Johnson, K.N.; and Scheurman, H.L. 1976. Timber for Oregon's tomorrow, an analysis of reasonable possible occurrences. Oregon State Univ., Ses. Bull. 19, Corvallis, OR, 111 p.

Brooks, D.J. and Kincaid, J.C. 1987. REACTT: An algorithm for solving spatial equilibrium problems. Gen. Tech. Rep. PNW-GTR-204. Portland, OR: U.S. Department of Agriculture, Forest Service, PNW Research Station. 37p.

deSteiguer, J.E. and Pye, J.M. (1988). Using scientific opinion to conduct forestry air pollution economic analysis. IN: A.Jobstl, ed., Proc. Symposium on the Economic Assessment of Damage Caused to Forests by Air Pollutants. IUFRO Working Party S4.04-02. Sept. 13-17, 1988. Gmunden, Austria.

Haynes, R.W. and Adams, D.M. 1985. Simulations of the effects of alternative assumptions on demand-supply determinants on the timber situation in the United States. U.S. Forest Service, Forest Resources Economics Research. Washington, D.C. 113 p.

Ince, P.J., Durbak, I., and Howard, J. (in press). The FPL Pulpwood Model: data, assumptions, and projections to the year 2040. Madison, WI: U.S. Department of Agriculture, Forest Service.

Kallio, M., Dykstra, D.P. and Binkley, C.S. 1987. The Global Forest Sector: An Analytical Perspective. John Wiley & Sons, New York. 703p.

Mills, J.R. 1988. Inventory, Growth, and Management Assumptions for the 1989 RPA Timber Assessment; Part I-The South and Part II-The North and West. Reports on file at the Pacific Northwest Research Station, Portland, OR.

NAPAP. 1988. Plan and schedule for NAPAP assessment reports 1989-1990 State of Science, State of Technology, Integrated Assessment. Review Draft. National Acid Precipitation Assessment Program. Washington, D.C. 286 p.

Schroeder, P. and A.R. Kiester. 1989. The Forest Response Program: National Research on Forest Decline and Air Pollution. Journal of Forestry 87(1):27-32

Tedder, P.L.; LaMont, R.N.; and Kincaid, J.C. 1987. The timber resource inventory model (TRIM): A projection model for timber supply and policy analysis. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 82 p.

USDA, Forest Service. (in press). An analysis of the timber situation in the United States: 1989-2040. Washington, D.C.

WEFA. 1987. Long-term alternative scenarios and 25-year extension: Annual model. August 1987. Wharton Econometric Forecasting Assoc. Bala Cynwyd, PA. 90 p.

APPLIED WELFARE ECONOMICS AND FOREST DAMAGE EVALUATION

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The traditional model of forest damage appraisal was developed to assist forest managers in determining the optimal level of forest protection for individual ownerships. The basic method combines microeconomic analysis with timber growth and yield models to estimate the difference between present values with and without damage. While theoretical support can be found for this approach, the traditional method needs modification for policy analysis at the market level.

A correct analysis of economic damages due to large-scale forest disturbance needs to quantify changes in aggregate economic welfare for timber producers and timber consumers. From society's viewpoint, failure to evaluate the aggregate impacts of forest damages results in biased damage estimates and potentially inefficient and inequitable damage control programs.

In this paper, simple and fairly precise empirical methods for evaluating aggregate economic welfare impacts of large-scale forest disturbances are developed based on a common theoretical model of landowner behavior. Two cases are modeled: (1) catastrophic forest damages due to southern pine beetle epidemics, and (2) growth-rate decline in natural stands of southern yellow pine. In both cases the analysis proceeds on the simplifying assumption that landowners are present value maximizers. While the methods developed preclude exact estimates of damages, lower-bound estimates are derived using the envelope theorem.

Empirical estimates of market price impacts of catastrophic forest damages are obtained using a structural time series model and historical timber price data. Welfare impacts are then derived using estimates of timber supply and demand elasticity. Economic damages due to pine growth-rate decline are estimated using information on historical rates of pine growth, changes in growth-rates, historical land-use patterns, and estimates of timber supply and demand elasticity. Finally, the policy implications of the models are discussed.

ECONOMIC CONSEQUENCES OF HETEROBASIDION ANNOSUM IN PICEA ABIES (KARST.)) STANDS - A STOCHASTIC ANALYSIS

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FDC: 443.3: 174.7 Picea abies Karst.: 172.8 Heterobasidion annosum: 652.54--015.5

The rot fungi *Heterobasidion annosum* causes nigh economic losses in the Nordic countries because it damages the most valuable part of the timber, and has an average annual growth in the tree height direction in the order of 0.25 m.

This paper aims at quantifying the economic effects of keeping Norway spruce (*Picea abies* Karst.) stands attacked by *Heterobasidion annosum*. The model used for this considers particularly the following factors:

- Basal-area and volume growth of the individual trees
- The initial position and growth of the rot fungi
- Mortality
- Changes in timber assortment over time
- Gross timber values and logging costs as a function of tree dimension, rot spread, and prices of the various assortments

All these factors are burdened with uncertainty. A vital aspect of the model is that it incorporates the aggregated total effects of all these uncertainty/risk factors. For this a stochastic simulation model is used, based on the SIMULA language. Estimates show that the economic costs of the rot fungi are high, and that the optimal rotation period is considerably shortened in stands attacked by this fungi.

FORECASTING DEMAND FOR SAWNWOOD OF LESSER-KNOWN TROPICAL SPECIES

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Peninsular Malaysia has the third largest tropical sawnwood industry in the world. Like processing industries in many other tropical regions, the industry is confronted by a declining inventory of the "well-known" species (WKS) that traditionally have comprised the bulk of its log input. Current levels of sawnwood production will be sustained only if the industry is able to use greater portions of so-called "lesser-known" species (LKS). This will depend on the marketability of sawnwood manufactured from these species.

Previous work (Vincent *et al.* in press) suggests that prospects are poor for export markets like Japan increasing their consumption of LKS. However, what are the prospects in domestic markets within tropical countries? This paper addresses this question. Domestic markets are arguably more important than export markets, as domestic consumption of tropical timber products has been rising faster than exports on a global basis. This trend is expected to continue, due to tropical countries' higher rates of population and income growth. Domestic markets already consume three-fifths of the sawnwood produced in Peninsular Malaysia.

Demand is analyzed for six categories of sawnwood consumed in Peninsular Malaysia during 1974-88. The categories represent species aggregations defined by density (heavy, medium, light) and marketability (WKS, LKS). The economic effects of variables affecting demand--for example, end-use activity, relative prices, and technical change--are studied by econometrically estimating a system of demand equations derived from a generalized Leontief cost function. The cost function is a multi-output one, because sawnwood has more than one end use (e.g., construction, furniture, moldings). The estimated demand equations are used to forecast consumption to 2010.

LITERATURE CITED

Vincent, J.R., Gandapur, A.K., and Brooks, D.J., in press: Species substitution and tropical log imports by Japan. *Forest Science*.

GROWTH IN THE UNITED STATES' MARKETS FOR SOLID HARDWOOD PRODUCTS

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The hardwood forests of North America are of prime economic importance. Among their many uses, the forests provide a viable industrial base for rural area economic development and highly valued wood products that benefit the consumer. This paper examines lumber use and other economic aspects of the United States' markets for solid hardwood products. These markets primarily use raw materials produced from forests in the United States, but also use imported temperate and tropical hardwoods as well as softwood products. Emphasis is on the nature and extent of hardwood lumber use (or lumber equivalent use) in the Nation's major solid-wood using industries and recent economic changes within these industries including growth patterns, employment effects, and community economic effects.

The major uses for solid hardwood products in the United States occur in the manufacturing and shipping industries and the export markets. Combined, these markets currently consume over 11.3 billion board feet of hardwood lumber annually. This represents a 37 percent increase in consumption since 1982. The industrial segments within the domestic market account for over 95 percent of the total consumption. In order of volumes consumed in 1987, these industries were: (1) pallets and containers, dimension and flooring, wood household furniture, millwork, and kitchen cabinets (which used over 8.6 billion board feet of solid hardwood products); and (2) railroad timbers, commercial furniture, upholstered furniture and the structural members group (which consumed about 2.1 billion board feet). Excluding railroad timbers, expectations are for continued increases in the volumes of solid hardwood product use in these industries for the near future. This is especially so in the pallet, furniture, dimension and flooring, millwork, and kitchen cabinet manufacturing segments.

These industries are in a growth mode and are becoming increasingly important to local economies. For example, these industries contained over 18,000 producing establishments in 1988 and accounted for an estimated $46 billion in product shipments. Average annual growth in value of shipments (deflated dollars) over the past 5 years ranged from 2.8 percent in the wood TV and radio cabinet industry to 19 percent per year in the wood kitchen cabinet sector. During this period, 7 of the 11 industries maintained an average growth rate of more than 10 percent per year. These firms directly employed over 640,000 persons with average annual increases in employment ranging from 3.3 to 11.2 percent. Other aggregate measures of economic activity within these industries are also positive which increases their value to a community, directly and indirectly, through their economic multiplier effects.

USING TOBIT ANALYSIS TO MODEL HARVEST BEHAVIOR IN THE PRIVATE SECTOR

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Surveys reveal that nonindustrial private forest-land owners, who control a majority of the commercial forest land in the United States, hold land primarily for reasons other than timber production. The multiple objective and dynamic nature of private ownership makes planning and estimation of timber availability from this sector extremely difficult.

Insight into the determinants of timber supply from private forests is provided through development of both theoretical and empirical models of harves behavior. A microeconomic model encompasses the multiple objective nature of private ownership by examining the harvest decision for owners who derive utility from forest amenities and from income used for the consumption of other goods. Comparative statics results are examined assuming a Cobb-Douglas utility function.

Tobit analysis, a form of censored regression, is used to estimate the relationship between harvest behavior and forest, owner, and economic characteristics from cross-sectional data for individually owned forest parcels. The results highlight the influence of forest characteristics and landowner affluence on the harvest decision. High per-acre volumes and the presence of commercially valuable species were important determinants of harvest behavior. An estimated supply elasticity of 1.06 corroborates the inventory elasticity assumed in several aggregate supply studies. Landowner affluence, as measured by years of formal educationand monetary income, was negatively correlated with timber harvesting. Positive coefficients and relatively high elasticities were obtained for stumpage prices; however the results were not significant at the 10% level. The apparent lack of price responsiveness may be due to the opposing influences of substitution and income effects.

Decomposition of the Tobit coefficients indicates that changes in timber supply are expected to result primarily from changes in the number of acres from which timber is offered for sale and to a much lesser extent from changes in per-acre harvesting intensity. Marginal supply responses varied considerably depending on the values for all coefficents and variables, underscoring the need to consider the shape of the distribution as well as the mean values for the explanatory variables when predicting harvest behavior.

LUMBER SUBSTITUTION IN JAPAN

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Japan is a major lumber consumer. It obtains its lumber principally through processing domestic and imported logs. A small but growing proportion is imported in processed form. Besides rising imports, other important changes are occurring in the Japanese lumber market. Examples include changing market shares for lumber from different geographic sources and changes in end-use patterns. Important questions, then, are: what are the sources, magnitudes, and limits of lumber substitution among different lumber categories.

Quantitative analysis is used to answer these questions. Specifically, substitution between lumber from different locational origins (domestic vs. imported), types (softwoods vs. hardwoods), and between lumber and non-wood substitutes is studied. Lumber categories included in the analysis are Japanese softwoods, Japanese hardwoods, imported tropical hardwoods, imported temperate softwoods, and imported temperate hardwoods. The three end-uses included in the model are residential construction, furniture, and packing materials. Presumed economic variables affecting lumber demand are relative factor prices, end-use output levels, and technological change.

A multi-output cost function is specified for the Japanese lumber-using industries. Two functional forms, the generalized Leontief and translog, are assumed for the cost function. The cost equation and the associated system of demand equations are estimated econometrically for the period 1970-88. The estimated model is put to two uses: to calculate own- and cross-price demand elasticities, and to forecast Japanese lumber consumption to the year 2010.

THE VALUE OF PRICE INFORMATION IN ROUNDWOOD MARKETS

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SUMMARY

The value of price information is essentially unknown in forestry. The existence of Timber Market South, a price reporting service for the southern US, gives us a chance to investigate this question. Our preliminary results are reported in Boyd and Hyde (1989) and repeated here. These results provide strong circumstantial evidence that price variation decreased from 1977 to 1981 due to TMS and that the gain to producers from better price information exceeds the costs of providing this information. Our research continues--with more recent data which may remove the circumstantial nature of our preliminary evidence.

Keywords: price variation, price stabilization

INTRODUCTION

This paper examines the potential price stabilizing impact of Timber Mart South (TMS), a recent publicly supported timber price reporting service. Stability is a well-reorganized economic objective and various price reporting and inventory stockpiling systems--particularly in agriculture--exist with this justification. Nevertheless, the empirical literature on the topic is sparse.[1] Turnovsky (1974) provides the summary model for measuring the gains from price stabilization.[2] He shows that gains arise in the sum of consumers' and producers' surpluses from decreases in price variation around a long-term mean. Schworm and Hyde (1983) show that considerable unexplained variation does, indeed, exist in any long sequence of forestry prices.

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[1] In the forest economics literature, Zivnuska (1949) first raised the issue. Scott (1955) also comments on it. To our knowledge it has gone otherwise unnoticed.

[2] Lesser and Bryant (1982) show the empirical gains from a retail store price reporting service in Ithaca, New York. Hayami and Peterson (1972) estimate the benefits from more general (usually quantity) reporting by the Statistical Reporting Service of the US Department of Agriculture. Newbery and Stiglitz (1981) provide the theory for an alternative analytical approach based on the economics of risk aversion.

Therefore, there is potential for an effective forestry price reporting service to decrease price variation and to produce social gain. To our knowledge, this paper is only the second empirical assessment of a price reporting service. [It follows Lesser and Bryant (1982).] It is the only assessment in forestry and the first to use the Turnovsky approach for measuring social gain.

TMS publishes monthly average prices for sales of pulpwood and sawtimber stumpage in 38 sub-state regions throughout the South and Southeast. TMS initially (1977-1980) received public financial assistance from the US Department of Agriculture but is now entirely private and self-supporting. Its success has encouraged the Department of Agriculture to expand stumpage price reporting services to other regions of the country, in particular the Northeast and the Lake States.

Millowners and large timber landowners have a good understanding of local stumpage market dynamics. Wood products are their full time business; therefore, they have sufficient incentive to keep themselves informed and TMS brings them little benefit. The situation is different, however, for the multitude of non-industrial private (NIPF) landowners. These landowners may be farmers and/or absentee landowners, usually with primary business interests and knowledge quite different from forestry. They may have little time to devote to forest management and personal cooperative advantage in other pursuits even if some of them have keen interests in their forestlands. For these NIPF landowners, TMS may provide the only reliable source of stumpage price information. (They can purchase advice from consulting foresters, but consultants may have some interest in providing landowners with a rosy picture of the market in order to convince the landowners to sell their timber and, thereby, to produce a commission for the consultants).

The impact of TMS may be large where its price information actually affects timber management and harvesting decisions. NIPF landowners, although individually small, in the aggregate account for 65 percent of the total timber harvest in the South and Southeast. They provide lesser, but still significant, shares of total harvests in the Northeast and the Lake States (56 and 59 percent, respectively) to which stumpage price reporting services have expanded (USDA 1982 p. 423). With better information on prices, these landowners presumably sell more in periods of high prices and withdraw from or delay entry into the market in periods of low prices. Their actions bring high prices down and encourage increases in low prices. The better information (such as produced by TMS) received by NIPF landowners, thereby yields a net stabilizing effect on long-term

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One of their conclusions is that quantity variation is more important than price variation.

prices. This stability effect is the source of increasing consumers' and producers' surpluses and social gain.

ANALYTICAL APPROACH

Price instability is defined by variation about the mean price, but wise price stabilization systems are designed to reduce only the unpredictable variation about the mean price. Firms adjust for themselves to predictable variation. Thus, the questions for our empirical analysis are: "Does price reporting help decrease the price variation and by how much? Do the benefits from price reporting exceed its costs?" The answers to these questions require price data from both before and after introduction of a price reporting service. TMS provides "after" data for a case study but there is no good source for "before" data. Indeed, if there were, then there would be no cause for TMS.

We develop an alternate approach to answering these questions but one which provides only impressionistic answers at best. The data available before TMS is southwide and annual. We first review economic measures of the supply and demand for stumpage and the stochastic variation around each from this data. Our second step measures the consumers' and producers' gains from potential decreases in the variation, some of which are surely decreases resulting from TMS. Finally, we inquire whether it is reasonable that these uncertain gains from TMS exceed its known costs.

DATA AND ANALYSIS

Newman (1988, revised) obtains demand and supply estimates using annual and South-wide data for the period ending with the introduction of TMS in 1977. We use Newman's estimates and follow Turnovsky (1974) in measuring the welfare effects of price variations around Newman's estimates.

The introduction of TMS decreases the price variations around Newman's estimates, but by an unknown amount. That is, there is insufficient annual data since 1978 to obtain econometrically satisfying demand and supply functions for comparing estimates of post-1977 price variations with the pre-1977 measures. Our alternative is to contrast the known costs of public support for TMS with the Newman-Turnovsky measures for decreases in demand and supply price variations that are just necessary to generate an off-setting gain in social welfare. The final step is to ask whether such decreases in price variations, therefore such gains in social welfare, are reasonable. Clearly, we cannot provide a definitive answer but our opinion is that public expenditure on TMS is probably a reasonable investment.[3]

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[3] There is also the possibility of redistribution from millowners to NIPF landowners. Millowners are more actively involved in the stumpage market than many NIPF landownes. They have better price information. Therefore, the real benefactors of TNS may be the NIPF landowners, and the

Southwide Demand and Supply for Stumpage: 1950 to 1977

Newman (1988, revised) provides 3SLS estimates of South-wide demand and supply for both sawtimber and pulpwood stumpage. Table 1 shows his revised estimates, including their variances, for the time period beginning in 1950 and ending in 1977 when TMS began reporting sawtimber and pulpwood prices.

The lagged quantity variable in Newman's demand equations shows the relation between stumpage quantity demanded and prior mill capacity. [It also reflects the importance of prior period expectations for the subsequent period. Schworm and Hyde (1983) follow a substantial body of economics literature in showing the importance of expectations rather than observed changes in producing economic gain.] All four equations display good statistical fits. Durbin-Watson and Durbin's h tests show that autocorrelation is not a great problem with this time series data. With one exception all signs on the independent variables satisfy expectations, the price elasticities are consistent with prior literature, and the coefficients are generally significant. The exception is the sign on paper prices in the pulpwood demand equation and this sign is insignificant.[4] We have no explanation for this sign, but a small coefficient and inelastic price-quantity relationship is reasonable for demand from the high fixed cost paper industry.

If we measure all of Newman's independent variables except the own-prices at their mean values, then these equations reduce to their Turnovsky forms. That is,

$$Q^D_t = a_o - a_1 p_t + u_t$$
$$Q^s_t = b_o + b_1 p_t + v_t$$

where Q^D_t and Q^S_t are the quantities demanded and supplied, respectively, p_t is the own-price, the a_1 and b_1 are constant coefficients and u_t, v_t are error terms. In this form, Newman's equations provide the information necessary to estimate the welfare gains from price stabilization.

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millowners may be the source of most of their benefits. Millowner opposition TMS supports this argument. The continued existence of paid subscriptions to TMS, many originating with forestry consultants and NIPF landowners, provides additional support. Furthermore, the latter argue that the redistribution must be at least sufficient to cover these subscription fees.

[4] The price elasticities are

$e^D_s = .0730$ $\qquad$ $e^s_s = .5821$

$e^D_p = .2836$ $\qquad$ $e^s_p = .3501$

where the superscripts refer to demand or supply and the subscripts refer to sawtimber or pulpwood.

Welfare Gains

Following Turnovsky's calculation, repeated in our appendix, A, the annual gains in social welfare for decreasing price variation to zero are $2.8 million for sawtimber and $1.2 million for pulpwood. Total reduction in price variation is an unreasonable expectation. Nevertheless, this shows that the potential gains are considerably in excess of the approximate $17,000 annual public expenditure for the first year's support of TMS. [5] Indeed, a very small share of these potential gains covers the public expenditure. It may be quite reasonable that public investment in TMS is socially efficient.

Table 2 records these social welfare results. It also records the producer and consumer shares which generate our observation that a larger proportion of the potential gains from price stabilization accrues to the logger and millowner consumers. The additional line of entries in table 2 takes one step further our observation that a small share of the potential gains justifies the public intervention. It shows the percent of the potential decrease in price variation necessary to justify public intervention if the entire decrease accumulates in either the sawtimber or the pulpwood market alone. If the two markets share the welfare effect equally, then these percentage decreases would be smaller yet. In all cases the necessary decrease in price variation is very small, therefore potentially reasonable.

Finally, we can consider further yet the proposition of efficiency by moving the Newman data three years forward to the period 1953-1980. This includes the first three year's experience with TMS yet maintains a sufficiently long data base for statistical analysis. We anticipate that, if TMS has a price stabilizing effect, then the variations associated with the three additional data years 1978-1980 are less that the variations associated with the three absent years 1950-1952. Therefore the variations associated with 1950-1977 and recorded in table 2. They can only reflect a small part of the full change in price variation due to the introduction of TMS, however, because fourteen of their seventeen years of data refer to pre-TMS evidence. Table 3 shows the new equations. The 1950-1977 and the 1953-1980 sawtimber equations are similar except that the latter show a better statistical fit as well as the anticipated smaller variances.

The 1953-1980 pulpwood equations show a slightly better fit but the pulpwood demand function shows a greater variance--contrary to expectation. The paper industry was just getting started in the South in the early 1950s. Therefore, there may have been a lower than usual price variation for pulpwood demand at that time and this may explain the one anomaly from among the four functions. In any case, the sawtimber market is bigger and more competitive than the pulpwood market. We anticipate a larger effect and greater importance to price stabilization in the sawtimber market. This anticipation is borne out.

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[5] Personal communication, James Neal, Regional Extension forester, USDA Forest Service, February 1986. Timber Mart-South received an initial $50,000 USDA Forest SErvice grant for subscriptions. The Forest Service distributed 951 TMS subscriptions in the first years to state foresters and state and country extension offices.

Table 3 also shows the welfare gains reflected in the differences between our two sets of equations. These gains are less that the anticipated gain if the general decline in price variation observed between the 1950-1977 equations and the 1953-1980 equations continues for another fourteen years, the period sufficient to permit confident comparison of pre-TMS data with data fully reflecting incorporation of TMS in the South-wide market. Nevertheless, even our observed gains from the short period exceed by thirty times ($538,000/$17,000) those gains necessary to justify the public investment in TMS. This provides further confidence, if not perfect evidence, that the public investment in TMS has been socially efficient. [6]

SUMMARY AND CONCLUSIONS

TMS provides an explicit market stabilizing intervention in forestry. Statistically convincing empirical tests of its impact on price stability must await better data or a longer period of observation. Our up-dated data and results (to be shared at the IUFRO Montreal meetings) may provide this evidence. Our strong circumstantial evidence, however, suggests (1) that even the smallest decrease in either sawtimber or pulpwood stumpage price variation would justify the TMS costs and (2) there has been an initial decrease in sawtimber price variation since 1977 and the first issue of TMS. This decrease, if due to TMS, is considerably more than sufficient to justify the initial public support of TMS and to encourage further inquiry into the merit of counterpart price reporting services for other regions of the country.

APPENDIX A: Turnovsky's Measures of Welfare Gains from Price Stabilization

Turnovsky's (1974) summary article reviews three well-known earlier articles (Waugh 1944, O 1961, Massell 1969) and provides both rigor and generalization for the argument that there are welfare gains to be captured with price stabilization.

Turnovsky begins with a single market in which linear relations describe demand D and supply S.

$$D(p_t) = a_o - a_1 p_t + u_t \quad (A.1)$$
$$S(p_t) = b_o + b_1 p_t + v_t \quad (A.2)$$

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[6] There is another potential gain from TMS which is not associated with stability. Price data is essential to economic and policy analysis. TMS provides the best stumpage price data in the US and, thereby, can make a large contribution over time to the rational evaluation of public policies. To the extent that this policy analysis leads to sore efficient public programs, then TMS contributes to social welfare.

where p_t equals current price; a_1, b_1 are deterministic constants (a_1, $b_1 \geq 0$); and u_t, v_t are additive stochastic disturbances generated by autoregressive processes.

$$u_t = \rho_1 u_{t-1} + e_{1t} \tag{A.3}$$
$$v_t = \rho_2 v_{t-1} + e_{2t} \tag{A.4}$$

where $-1 < \rho_1, \rho_2 < 1$ and e_{1t}, e_{2t}, have zero means and variances $\sigma^2_{e1}, \sigma^2_{e2}$ with zero covariance.

Equations (A.1) and (A.2) imply that

$$\begin{aligned} &E(u_t) = v_t) = 0 \\ &E(u^2_t) = \sigma^2_u = \sigma^2_v = \sigma^2_{e1}/(1 - \rho^2_1) \\ &E(v^2_t) = \sigma^2_v = \sigma^2_v = \sigma^2_{e1}/(1 - \rho^2_2) \\ &E(u_t v_t) = 0 \end{aligned} \tag{A.5}$$

In the absence of price stability, the equilibrium price is

$$p_t = (u_t - v_t + a_o - b_o)/(a_1 + b_1) \tag{A.6}$$

and the equilibrium quantity is

$$D(p_t) = S(p_t) = \frac{b_o a_1 + b_1 a_o}{a_1 + b_1} + \frac{a_1 v_t + b_1 u_t}{a_1 + b_1} \tag{A.7}$$

In the presence of a price stabilizing mechanism, then p_s is such that

$$E(D_t) = E\ (S_t) \tag{A.8}$$

so that the market balances on the average. Stabilization requires continual trade of an amount

$$x_t = v_t - u_t, \tag{A.9}$$

the expected value of which equals zero.

Taking the expected value of equation (A.6) yields

$$E(p_t) = (ao - b_o)/(a_1 + b_1) = p_s \tag{A.10}$$

and the corresponding quantities

$$D(p_s) = u_t + (b_o a_1 + b_1 a_o)/(a_1 + b_1) \tag{A.11}$$

LITERATURE CITED

Boyd, R., and W. F. Hyde, 1989: Forestry Sector Intervention. Ames: Iowa State University Press, pp. 106-119.

Hayami, Y., and W. Peterson, 1972: Social returns to public information services. American Economic Review 69 (1):119-30.

Lesser, W. H., and W. K. Bryant, 1982: Predicting the direct benefits of a food price-reporting or preference-changing program. American Journal of Agricultural Economics 64:129-33.

Massell, B. F., 1969: Price stabilization and welfare. Quarterly Journal of Economics 83: 284-298.

Newbery, D. M. G., and J. E. Stiglitz, 1981: The theory of commodity and price stabilization: a study in the economics of risk. New York: Clarendon Press.

Newman, D. H., 1988: An econometric analysis of aggregate technical change in southern softwood forestry. Unpublished Ph.D. dissertation, Duke University, Durham, NC.

Oi, W. Y., 1961: The desirability of price instability under perfect competition. Econometrica 29:58-64, 248.

Schworm, W., and W. Hyde, 1983: An investigation of the price volatility of timber and lumber supplies in the US. In J. Royer and C. Risbrudt, eds., Nonindustrial private forests. Durham: Duke University School of Forestry, pp. 93-108.

Scott, A., 1955: Natural resources: the economics of conservation. Carleton Library Series No. 3. Ottawa: Carleton University Press.

Turnovsky., S. J., 1974: Price expectations and the welfare gains from price stabilization. American Journal of Agricultural Economics 56:206-716.

US Department of Agriculture, Forest Service, 1982: An analysis of the timber situation in the United States 1952-2030. Forest Resource Report No. 23. Washington, DC: US Government Printing Office.

Waugh. F. V., 1944: Does the consumer benefit from price instability? Quarterly Journal of Economics 58:602-614.

Zivnuska, J. A., 1949: Commercial forestry in an unstable economy. Journal of Forestry 47(1):4-13.

Table 1: Southwide demand and supply for sawtimber and pulpwood stumpage, 1950-1977

Sawtimber

$$Q^D_{st} = \underset{(-2.1438)^{**}}{-1938525} - \underset{(-1.7011)^{*}}{3915.9p_{st}} + \underset{(2.0821)^{**}}{25314.61p_{lt}} + \underset{(1.6675)}{126291.2w_{lt}}$$

$$+ \underset{(0.8883)}{997100.6r_{lt}} + \underset{(5.8298)^{**}}{.833833Q_{st-1}}$$

$R^2 = .8771$ Durbin's h = .461 $\sigma^2 = 11,455,346,990$

$$Q^S_{st} = \underset{(5.3923)^{**}}{930106} + \underset{(7.7108)^{**}}{3242.307p_{st}} + \underset{(3.8511)^{**}}{.006618I_t} - \underset{(-6.6251)^{**}}{12487.6p_{pt}}$$

$R^2 = .8930$ Durbin-Watson = 1.316 $\sigma^2 = 9,108,449,870$

Pulpwood

$$Q^D_{pt} = \underset{(1.111)}{843290.4} - \underset{(-0.8125)}{5742.64p_{pt}} - \underset{(-0.3849)}{3606.42p_{at}} + \underset{(1.8428)^{*}}{226719.8w_{at}}$$

$$- \underset{(-1.0593)}{2183427r_{at}} + \underset{(3.5911)^{**}}{0.573133Q_{pt-1}}$$

$R^2 = .9366$ Durbin's h = .052 $\sigma^2 = 8,652,809,938$

$$Q^S_{pt} = \underset{(-5.1860)^{**}}{-918345} + \underset{(3.3402)^{**}}{7088.792p_{pt}} + \underset{(14.7363)^{**}}{0.021682I_t} + \underset{(2.0012)^{*}}{684.8042p_{st}}$$

$R^2 = .9454$ Durbin-Watson = 1.172 $\sigma^2 = 6,795,482,204$

where:

Q^D_{st}, Q^Sst = quantities of sawtimber stumpage demanded and supplied in year t (for lumber and plywood, in Mcf)

Q^D_{pt}, Q^S_{pt} = quantities of pulpwood stumpage demanded and supplied in year t (no residues, in Mcf)

p_{st}, p_{pt}, p_{lt}, p_{at} = real prices of sawtimber stumpage, pulpwood stumpage, lumber (national index), and paper (national index), in year t

I_t = total standing timber inventory in year t (in Mcf)

w_{lt}, w_{at} = real wages in lumber and paper, in year t

r_{lt}, r_{at} = real capital costs in lumber and paper, in year t

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The numbers in parentheses are t-statistics.

* Indicates significant at the .10 level.

** Indicates significant at the .05 level.

Table 2: Stumpage Price Variation in the South: 1950-1977

Welfare Gains Due to 100% Decrease in Price Variation (1977$)

	Sawtimber	Pulpwood	Total
Producers' Surplus	1,207,616	382,645	1,590,261
Consumers' Surplus	1,581.832	786,386	2,368.218
Social Welfare	2,789,448	1,169,027	3,958.475

Decrease in Price Variation Sufficient to Create Annual Social Welfare Gains Exceeding the Public Investment in Timber-Mart South

	Sawtimber	Pulpwood
Decrease in Price Variation	0.6%	1.5%

Table 3: Welfare Gains Due to the Difference in Price Variation between the 1950-1977 Equations and the 1953-1980 Equations (1977$)

	Sawtimber	Pulpwood	Total
Producers' Surplus	667,999	-514,715	153,284
Consumers' Surplus	178,848	205,968	384,816
Social Welfare	846,847	-308,747	538,100

Underlying Equations[1]

Sawtimber Equations: 1953-1980

$$Q^D_{st} = \underset{(-4.1026)^{**}}{-1964033} - \underset{(-2.8891)^{**}}{3831.03p_{st}} + \underset{(3.9011)^{**}}{25900.96p_{lt}} + \underset{(3.204)^{**}}{163726.8w_{lt}}$$

$$+ \underset{(2.0237)^{*}}{1692907r_{lt}} + \underset{(4.1241)^{**}}{.668643Q_{st-1}}$$

$R^2 = .9517$ Durbin's h = .975 $\sigma^2 = 7{,}771{,}806{,}186$

$$Q^S_{st} = \underset{(3.6982)^{**}}{673254.2} + \underset{(7.9070)^{**}}{2785.987p_{st}} + \underset{(4.9765)^{**}}{.009084I_t} - \underset{(-6.5712)^{**}}{10480.6p_{pt}}$$

$R^2 = .9539$ Durbin-Watson = 1.716 $\sigma^2 = 6{,}785{,}037{,}557$

Pulpwood Equations: 1953-1980

$$Q^D_{pt} = \underset{(1.3026)}{1341073} - \underset{(-1.4377)}{6769.91p_{pt}} - \underset{(-.7051)}{6746.51p_{st}} + \underset{(3.0190)^{**}}{222671.1w_{pt}}$$

$$- \underset{(-1.4531)}{1378917r_{pt}} + \underset{(3.0944)^{**}}{.470529Q_{pt-1}}$$

$R^2 = .8943$ Durbin's h = 1.562 $\sigma^2 = 12{,}945{,}053{,}520$

$$Q^S_{pt} = \underset{(-3.2542)^{**}}{-741869} + \underset{(2.4476)^{**}}{5322.683p_{pt}} + \underset{(12.4400)^{**}}{.02114I_t} + \underset{(2.2804)^{**}}{703.185p_{st}}$$

$R^2 = .9421$ Durbin-Watson = 1.175 $\sigma^2 = 6{,}468{,}938{,}917$

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[1] All definitions are as in table 1.

NONINDUSTRIAL PRIVATE FOREST OWNERS' TIMBER SUPPLY AND LIFE CYCLE HARVEST IN FINLAND

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ABSTRACT: The timber supply and life cycle harvesting behaviour of nonindustrial private forest owners is studied by assuming effective (perceived) credit rationing. A timber supply function is estimated using Finnish micro data and the tobit model in order that the decision to enter the market and the decision how much to sell can be handled simultaneously. According to the results the hypothesis of an imperfect capital market cannot be rejected. The variables which under a perfect capital market and perfect knowledge do not affect harvesting behaviour have significant coefficients in the estimated timber supply function. Further, the average harvest of different age categories of otherwise similar forest owners decreases monotonically with the age of the owners. This supports a nonconstant lifetime harvesting pattern predicted by the life cycle model under (perceived) credit rationing.

Acknowledgements: Karl–Gustaf Löfgren's support during the study and comments on uncountable versions of manuscripts and Ville Ovaskainen's helpful comments on the present paper are gratefully acknowledged. The remaining errors are our own responsibility.

1. INTRODUCTION

The harvesting behaviour of nonindustrial private forest (NIPF) owners is of continuing interest in many countries, as they are important suppliers of raw material to the forest–based industries. In a perfect capital market with perfect knowledge and foresight, supply of timber and consumption of goods and services are solved independently of each other. Therefore, supply of timber is determined by the present and future values of (net)timber prices and interest rates (and, out of equilibrium, also by the stock of growing merchantable timber). Using the empirical evidence from the Finnish case, we demonstrate that this separability does not necessarily extend to the empirically observable timber supply of NIPF owners. Rather, harvesting decisions seem to be dependent on forest owners' preferences. One explanation for this are imperfections in the capital market (cf. Koskela (1989)) which can also be perceived. This means that NIPF owners use their forest as a bank even if they actually have the possibility of using the capital market to pursue present value maximizing harvesting policy.

Several studies in Scandinavia have found a connection between owner characteristics (wealth, income, owner's age etc) and timber supply (Järveläinen (1981, 1988), Loikkanen et al (1986) and Carlen (1986)), indicating market imperfections. Binkley (1981) demonstrated that, according to data from New Hampshire, USA, harvesting frequency was affected not only by timber prices but by nonforestry incomes and forest land area. However, in many earlier studies either the theoretical background has been inadequately specified and/or the available data, especially the information concerning NIPF owners' actual harvest, harvesting potential, incomes and wealth, have been poor. Moreover, the connection between the short–term timber supply and forest owners' life cycle planning has not been well understood.

Kuuluvainen (1989) used a Fisherian intertemporal savings – consumption model to derive the "nonrationed and rationed" short–term timber supply functions and a deterministic continuous time optimal control model to demonstrate the possible life cycle harvesting patterns of NIPF land owners (see also Lohmander (1983), Koskela (1989), Kuuluvainen (1990), Ollikainen (1987) and Ovaskainen (1987)). In this paper the theoretical background is discussed and the estimation results of a short–term timber supply function using cross-section time series data from Finland are presented.

2 THEORETICAL BACKGROUND

2.1 SHORT–TERM TIMBER SUPPLY

Assume that the forest owner behaves as if he is maximizing utility over two periods (the present, period 1, and the future, as described by period 2). Utility is an increasing, strictly concave function of the consumption of goods and services (c_1 and c_2) and the bequeathed end–of–second–period timber stock (v_2), and additively separable over time (cf. Ovaskainen (1987), Koskela (1989) and Kuuluvainen (1990)). The forest owner has exogenous income (m_1 and m_2) and timber sale income, q_1h_1 and q_2h_2, where q_1 and q_2 are net per unit timber prices, and h_1 and h_2 are the timber quantities sold during the two periods, respectively. The forest owner's subjective rate of discount of future utility is denoted by δ. The forest owner may borrow at the given market interest rate, r, but only up to an exogenously given credit limit $\overline{B}$. His net (nonforest) assets at the end of the first period are denoted by a. The forest owner's problem can be written as follows,

$$\underset{c_1, c_2, h_1, h_2}{\text{Maximize}} \quad U = u(c_1) + u(c_2)(1+\delta)^{-1} + b(v_2)(1+\delta)^{-1} \tag{1}$$

$$\text{s.t.} \quad v_1 = v_0 - h_1 \tag{2a}$$

$$v_2 = v_0 + f(v_0 - h_1) - h_1 - h_2 \tag{2b}$$

$$c_1 = m_1 + q_1 h_1 - a \tag{2c}$$

$$c_2 = a(1 + r) + m_2 + q_2 h_2 \tag{2d}$$

$$h_1, h_2, c_1, c_2 \geq 0, \tag{2e}$$

$$a \geq -\overline{B} \tag{2f}$$

The owner chooses those combinations of consumption and harvest which maximize his utility over the planning period, subject to the constraints (2a) to (2f). Growth is a strictly concave function of timber stock after the harvest in the first period, $(v_0 - h_1)$. The growth function approximates regulated unevenaged forest management, where marginal units are trees or evenaged stands. Land rent considerations (or the effect of an infinite cycle of rotations) are ignored.

To obtain a perfect capital market solution, assume initially that the borrowing constraint (2f) is not binding. From the first order conditions the equilibrium condition for timber supply and consumption (demand for loans) during the first period is obtained,

$$[1 + f'(v_0 - h_1)]q_2/q_1 = (1 + r) = [u'(c_1)(1 + \delta)]/u'(c_2), \tag{3}$$

where $[1 + f'(v_0 - h_1)]q_2/q_1 = 1 + r$ is the familiar equilibrium condition for the harvest from the economics of natural renewable resources. Equation (3) shows that under a perfect capital market, consumption and production decisions are separate. The income from the present value maximizing harvest can be allocated for optimal consumption via the capital market. The equilibrium condition can be solved for h_1 to obtain the first period behavioural timber supply function,

$$h_1 = h(\underset{+}{q_1}, \underset{-}{q_2}, \underset{+}{r}, \underset{+}{v_0}). \tag{4}$$

How do the harvesting decisions depend on the exogenous variables of the model when the credit limit, $\overline{B}$, is actually binding? If the forest owner wanted to borrow more than allowed by the given credit limit, the credit limit would become an exogenous variable. In this case the equilibrium condition for the optimal first period harvest (and consumption) becomes,

$$[1 + f'(v_0 - \tilde{h}_1)]q_2/q_1 = [u'(\tilde{c}_1)(1 + \delta)]/u'(\tilde{c}_2), \tag{5}$$

where (~) refers to the credit–rationed allocation. The implication of (5) is that harvesting and consumption decisions are now made simultaneously (compare equation (3)). The marginal revenue from postponing the harvest for one period is equated to the marginal rate of time preference. With a binding credit limit, the optimal intertemporal allocation of resources via the capital market is not possible, so the interest rate does not explicitly enter the equilibrium condition.

The behavioural (ordinary) timber supply function in the first period solved from the equilibrium condition in equation (5) can be written as follows,

$$\tilde{h}_1 = \tilde{h}(\underset{?}{q_1}, \underset{?}{q_2}, \underset{-}{m_1}, \underset{+}{m_2}, \underset{-}{r}, \underset{-}{\bar{B}}, \underset{+}{\delta}, \underset{+}{v_0}). \tag{6}$$

Compared to equation (4) the supply equation now includes the "preference" variables (m_1, m_2 $\bar{B}$, δ), and therefore has an obvious empirical implication, especially if micro data are available. As in the case of equation (4), the signs under the variables are obtained by a straightforward comparative statics exercise. Under effective credit rationing, timber prices have both a positive substitution and a negative income effect and the total effect remains a priori ambiguous. The effect of the present timber price is smaller than the price effect in the perfect capital market and can even be negative. The market interest rate has only an income effect on the credit–rationed timber supply, which is negative, contrary to the positive effect in the perfect capital market (Kuuluvainen (1990); see also Ollikainen (1987)).

The bequest function has been added to the problem because in the next section the formulation is interpreted as describing the life cycle planning of a NIPF owner. Therefore, the second period harvest is also a truly endogenous variable determined by the equilibrium conditions for the harvest and for the desired terminal stock. The latter says that the bequeathed timber stock must at the margin bring the same utility to the owner as consumption during the same period. It is worth noting that the relative size of the harvest in the first period as compared to the harvest in the second period is not affected by the bequest motive, as can be seen from equilibrium conditions (3) and (5). Nevertheless, the overall level of the harvest during the life cycle is affected by the bequest motive, because the higher the desired terminal stock the less can be harvested during the planning period.

2.2 THE "LIFE CYCLE" HARVEST

The optimal life cycle harvesting – consumption – savings patterns could be derived as a solution to the life time utility maximization problem using a deterministic, continuous time optimal control model (Kuuluvainen (1989); see also Shah (1981), Tobin (1967, 1972) and Yaari (1964)). We shall discuss the main results by interpreting the above two period model as describing forest owners' life cycle. Assume that the owner expects a constant lifetime income ($m_1=m_2=M$) and timber price ($q_1=q_2=Q$). If the capital market is perfect, the present value maximizing harvest leads to the maximum utility of consumption during the lifetime. In this case, a continuous time life cycle model with a terminal date known with certainty predicts a constant life cycle harvest, excluding the possible adjustment periods at the beginning and at the end of the planning period. Therefore, if one observes the life cycle harvest in a perfect capital market, other things being equal, there should be no systematic variation in the harvest or in the timber stock per hectare related to the age of the owner.

If the forest owner perceives a binding credit limit, the equilibrium condition (5), now interpreted in the life cycle sense, shows that consumption and harvesting decisions must be made simultaneously. To help the interpretation, assume a logarithmic (constant elasticity of substitution) utility function so that $u'(c_1) = \gamma/c_1$, $u'(c_2) = \gamma/c_2$ and $b'(v_2) = \beta/v_2$, where γ and β are the weights of the utility of consumption of goods and services and the bequeathed timber stock and $\gamma + \alpha = 1$. However, any other strictly concave utility function would give the same qualitative results. The equilibrium condition (5) can now be written,

$$\frac{c_2}{c_1} = \frac{M + Qh_2}{M + Qh_1} = \frac{1 + f'(v_0 - h_1)}{1 + \delta} \gtreqless 1 \qquad (7)$$

It has been assumed that $\overline{B}$, the credit limit, is zero, because the effect of nonzero loans on the optimal harvesting profile is obvious. The first equality follows by substituting for consumption from the budget constraints (2c) and (2e) when $\overline{B} = -a = 0$. First, we note that $\delta > r$, i.e. the subjective rate of discount has to be greater than the market interest rate, otherwise the owner would not want to borrow, and could not become credit-rationed during the first period of his life cycle. If $f'(v_0 - h_1)$ is greater (equal to, smaller) than δ, the forest owner will be harvesting (and consuming) less (as much as, more) during the first period of his life cycle than during the second when $m_1 = m_2 = M$ and $q_1 = q_2 = Q$, i.e. when incomes and stumpage prices are constant. With the logarithmic utility function, the desired terminal stock is given by $v_2^* = \beta c_2/\gamma Q$. The greater the weight of the bequeathed timber stock the larger the desired terminal stock. If $\beta = 0$, i.e. the owner does not value the bequeathed timber stock, he will harvest all merchantable timber during the second period.

Although it is not obvious from the two period formulation, the life cycle harvesting (and consumption) pattern can also be hump-shaped. The marginal growth rate of the timber stock, $f'(v_0 - h_1)$, can be greater than the subjective rate of discount at the beginning of the life cycle if the owner has, for example, bequeathed a forest with relatively low stocking. It may then be optimal to increase the harvest and consumption initially, but still harvest less than the growth in such a way that at some point in time $f'(v_t - h_t)$ becomes smaller than δ and the harvest (and consumption) starts to decrease in order to meet a relatively large desired terminal stock. From (7) the effects of nonconstant exogenous income and timber prices are obvious. For example, if the owner expects future income to be higher than income in the present period, he can attain the initial utility level from consumption by harvesting less during the first period than he would do if he expected a constant income profile. The important point to note is that incomes, the subjective rate of discount and the credit limit affect the optimal harvesting pattern only if the credit limit is binding.

Because the bequeathed timber stock is valued, the owner may well be harvesting less during the second part of his life cycle even if the timber stock is larger than he had during the first period. We are unable to directly observe the subjective rate of discount or the desired terminal stock. However, the deviations of the subjective rate of discount from the market interest rate may cause the age of the owner to become a relevant independent variable in the timber supply function when (perceived) credit rationing is effective. Of course, the deviations of the desired terminal stock from the present value maximizing stock level may cause adjustment periods at the beginning and at the end of the end of the life cycle even when the capital market is perfect. However, under a perfect capital market the latter deviations are much harder to justify, and would predict rather extreme reactions in harvest and timber stock at the beginning and at the end of the life cycle (using the optimal control concepts, bang–bang solutions would be optimal).

3 THE DATA

Cross-section time series data will be used to estimate a timber supply function by allowing for a nonconstant life cycle harvesting pattern. We use survey data collected in 1985 and 1986 using personal interviews from a sample of 370 NIPF owners in southern Finland whose forests were also inventoried at the time of the interview. The data set is augmented by annual micro data on forest owners' incomes and wealth and by four regional price series and the aggregate annual interest rate. The structure of the Finnish timber market indicates that regional prices can be used to describe the timber prices experienced by the NIPF owners. Regional prices are quantity–weighted annual averages of prices of different timber assortments. The data on timber sales and timber stock are from the five years preceeding the interview. For a detailed description of the data the reader is referred to Karppinen and Hänninen (1988).

Direct information on whether the owner perceives a constraint in the capital market is not available. This means that the credit limit cannot be included as an explanatory variable in the supply equation to be estimated. However, if the coefficients of those variables which do not theoretically affect the timber supply under a perfect capital market become statistically significant, the hypothesis of an imperfect capital market timber supply cannot be rejected.

4 ESTIMATION RESULTS

In this section, we report the results of the tobit model explaining simultaneously the decision to enter the market and the decision how much to sell (Maddala (1983)). The results of a regression model explaining the growing timber stock are presented in order to see how the timber stock varies as a function of forest owners' age. The latent variable of the tobit model, the harvesting intensity, is denoted by h^*_{tij}. It is assumed that the harvesting intensity can be positive, negative or zero even though the actual harvest has to be non–negative. It is further assumed that the intensity is a linear function of the vector x_{tij} of the exogenous variables to be defined shortly. The tobit model uses the information available for h^*_{tij} above zero. Therefore,

$$\begin{aligned} h^*_{tij} &= h_{tij} = \beta' x_{tij} + \epsilon_{tij} && \text{if the right–hand side is positive} \\ h_{tij} &= 0 && \text{otherwise,} \end{aligned} \tag{8}$$

where h_{tij} is the actual harvest of owner i in Forestry Board District j and in year (felling season) t. Further, β is the vector of the parameters to be estimated and ϵ_{tij} is the normally distributed error term. In the tobit estimation it has been assumed that each forest owner in each year is an independent observation, which means that all coefficients are assumed constant and that the disturbance captures the differences over time and individuals (Judge et al. (1985)). Obviously, this assumption is rather restrictive. Because the observation period for individual forest owners varies from 2 to 5 years, most of the variation in the micro variables is due to the variation between the cross–sectional units. Exogenous variables of the model are as follows (the first sign under the variable refers to perfect capital market supply reaction and is zero when the variable does not enter the perfect capital market timber supply function, the second sign refers to the credit rationed reaction),

$$x_{tij} = (\underset{+/?}{q_{tj}},\ \underset{-/?}{q_{(t-1)j}},\ \underset{+/-}{MRI_t},\ \underset{+/+}{v_{(t-1)i}},\ \underset{0/-}{m_{ti}},\ \underset{0/+}{\overline{w}_i},\ \underset{0/?}{age35a_{ti}},\ \underset{0/+}{age3550_{ti}},\ \underset{0/+}{age5065_{ti}},\underset{0/?}{OCC_i},\underset{?/?}{AR_i})$$

where:

q_{tj} = present real stumpage price,
$q_{(t-1)j}$ = real stumpage price lagged by one period,
MRI_t = real rate of interest,
$v_{(t-1)i}$ = beginning–of–period timber stock (per hectare),
m_{ti} = total before tax income,
$\overline{w}_i$ = average wealth of owner i during the observation period
$age35u_{ti}$ = forest owner i is under 35 years of age,
$age3550_{ti}$ = forest owner i is 35 years or older but under 50,
$age5065_{ti}$ = forest owner i is 50 years or older but under 65, (owners over 65 years of age are the zero case),
OCC_i = farmer = 0, nonfarmer = 1),
AR_i = forest land area; holdings of 30 hectares or less = 0, holdings over 30 hectares = 1.

All monetary units are measured in real terms deflated by the wholesale price index (the base year is 1985). The effect of present and future prices are a priori undetermined when credit rationing is effective. Price expectations are assumed to be regressive, i.e. prices in the future are expected return to some "normal" level, here represented by the price in the previous period. For credit–rationed forest owners the expected sign of the interest rate is negative, because under credit rationing the interest rate has a negative income effect on the first period timber supply. As shown by Kuuluvainen (1990), the larger the loans the stronger the negative income effect of the interest rate, i.e. the more interest has to be paid in the future the more of the present harvest has to be allocated to the future. If the forest owner has no loans the effect on the present harvest is zero. Since the sample obviously contains both nonrationed forest owners and forest owners who perceive credit limits, the expected sign of the interest rate is a priori undetermined. An increase in the present income decreases the timber supply of a credit–rationed forest owner. The wealth of the owner can be used as a proxy for the expected long–term ("life cycle") income and has a positive effect on the present harvest for credit–rationed forest owners.

The effect of the subjective rate of discount, or rather the effect of the difference between the subjective rate of discount and the borrowing interest rate, can be revealed by including the age of the owner in the short–term timber supply function. If the subjective rate of discount is larger than the interest rate and the forest owner, loosely speaking, wants to bequeath a relatively large stock, the average rate of harvest will be decreasing towards the end of the life cycle. Initially, it can either increase or decrease depending on the size of the stock at the beginning of the life cycle. (The timber stock should be increasing at the end of the life cycle.) Therefore, we expect a declining average harvest rate towards the end of the life cycle. It can be shown that the absolute sizes of the effects of the preference variables (present and expected income and subjective rate of discount) are independent of the degree of credit rationing (Kuuluvainen (1990)). Hence, these variables should become statistically significant in the estimations whenever credit rationing is present. The forest owner's occupation and the forest land area are also included in the model although they are not included in the theoretical discussion above. They can be related to preferences and economies of scale in timber production (sales), respectively.

The number of observations used in the estimations was 1579. The informal residual analysis and the Breusch–Pagan test on OLS residuals (Judge (1985), p. 446) suggested the use of the per–hectare figures so as to reduce heteroscedasticity. The standard tobit model was used as the informal residual analysis did not give cause for concern when the per hectare figures were used. The results of the tobit model are presented in table 1. Both the elasticities of expected supply (=sales) for all observations, and for those observations which are above the zero limit, i.e. observations for which the harvest is positive at the constant values of the exogenous variables, are reported. The estimated coefficients of the tobit model are significant at the 1 per cent level and the micro variables even at the 0.1 per cent level, except for the coefficients of the lagged stumpage price and owner's occupation.

According to the results of the tobit model given in table 1 the hypothesis of credit–rationed timber supply behaviour cannot be rejected as the "preference" variables have highly significant coefficients. However, the signs of those variables which enter both rationed and non–rationed timber supply functions do not seem to be affected by the nonseparability of supply from preferences. The coefficient of the interest rate becomes positive. Because it is also significant at the 1 per cent level, it contradicts the theoretical credit–rationed timber supply equation, where the sign of the interest rate is negative. This might mean that credit rationing is not very strong, or that the loans of the forest owners perceiving credit limits are relatively small so that the positive effect of the interest rate of nonrationed forest owners dominates. When the interest rate was included in the supply estimation using a data set from the late 1970's (Loikkanen et al. (1986)), it obtained a negative and statistically significant coefficient. The difference between the 1970's and the present observation period may be due to the gradual deregulation of the capital market in Finland since the beginning of the 1980's. However, as the interest rate has only temporal variation, rather than being the interest rate experienced by an individual forest owner, it may capture the year–specific demand factors which are not represented by the stumpage price.

The elasticity of the expected average supply with respect to the stumpage price, which is 2.2, is much higher than the other elasticities in absolute terms. High elasticities for stumpage prices have been estimated elsewhere in Scandinavia (cf. Carlén (1986); see also Kuuluvainen (1986) and Ovaskainen (1987)). High elasticities in the cross–sectional studies may be partly due to the lack of individual price data, which causes the price variation to become underestimated even if the buyers apparently do not actively discriminate between the sellers. The elasticity of the average supply with respect to the growing timber stock per hectare is 0.40 and with respect to the exogenous income and average wealth –0.25 and 0.15, respectively. The effect of the forest land area being over 30 hectares is about 0.8 cu.m/ha/year, while there is practically no difference between the average expected sales of farmers and nonfarmers. The effect of the forest land area is mainly due to the low average harvest of very small (under 10 hectares) holdings.

Expected sales decrease monotonically from the youngest to the oldest age category. When the other variables are held at their means, the expected sales decrease by about 2.7 cu.m/ha/year when moving from the under 35 years age category to the over 65 years age category of forest owners. Consequently, a nonconstant monotonically decreasing harvesting pattern over the age categories of the owners is implied. As a matter of fact, experiments with different subsamples also gave the same result, when the forest owners with taxable wealth under the sample average were disregarded

Table 1 The estimated tobit coefficients and elasticities[1],[2] and the coefficients of the linear regression model explaining the timber stock. The statistical significance of the estimated coefficients is denoted by superscript stars, values in parentheses are standard errors of estimates.

Independent variable	Tobit coefficients	Elasticity	Elasticity above limit	Regression cofficients
constant	–18.079*			10.169*
	(7.164)			(4.776)
q_{tj}	0.086**	2.16	0.84	–0.052**
	(0.028)			(0.017)
$q_{(t-1)j}$	–0.008	–0.20	–0.08	0.010
	(0.033)			(0.022)
MRI_t	0.358**	0.50	0.19	–0.168*
	(0.005)			(0.084)
$v_{(t-1)i}$	0.018***	0.40	0.15	1.012***
	(0.005)			(0.003)
m_{ti}	–0.014***	–0.25	–0.10	0.006***
	(0.003)			(0.002)
$\overline{w}_i$	0.009***	0.15	0.06	–0.0006
	(0.0006)			(0.0003)
$age35u_{ti}$	4.159***	2.65[2]	1.87	–2.207***
	(0.692)			(0.560)
$age3550_{ti}$	3.972***	2.35[2]	1.67	–1.755***
	(0.603)			(0.317)
$age5065_{ti}$	2.824***	1.61[2]	1.14	–1.413***
	(0.564)			(0.313)
OCC_i	–0.127	–0.07[2]	–0.05	–0.761*
	(0.418)			(0.359)
AR_i	1.407***	0.76[2]	0.54	–0.582*
	(0.414)			(0.321)
log–likelihood			–3725.90	
number of observations			1579	1579
R^2			0.04	0.99
Value of the distribution function,			0.547	
Expected average sales, cu.m/ha/year			3.09	
Expected sales above zero, cu.m/ha/year			5.66	

* significant at 5 per cent level according to the asymptotic t–test,

** significant at 1 per cent level according to the asymptotic t–test,

*** significant at 0.1 per cent level according to the asymptotic t–test

[1] Elasticities are calculated at the means of the variables.

[2] The difference in expected sales cu.m/ha/year when x = 1 and x = 0.

(Kuuluvainen (1989) p. 177). For them, the life cycle harvest seems to be humped–shaped while timber stock increases monotonically. Both harvesting patterns are in accordance with the life cycle model when the NIPF owner becomes rationed in the capital market and wants to leave a relatively large terminal stock to his inheritors.

The life cycle hypothesis of harvest receives further support from the results of a linear regression model for the end–of–period timber stock per hectare (table 1). In this model, too, the three age categories become statistically significant when compared to the oldest forest owners. The timber stock increases with the owner's age. Thus, old forest owners have a larger average stock than young ones (other things being equal) but they nevertheless sell less timber than the young forest owners! The estimated results therefore support the life cycle behaviour of harvest and timber stock in the sample used in the study depicted in figures 1a and 1b. The average harvest of forest owners under 35 years of age is 4.1 cu.m/ha/year and decreases monotonically to 1.8 cu.m/ha/year for forest owners over 65 years of age. The difference is 2.3 cu.m/ha/year. (The tobit model predicts a slightly stronger decrease in the harvest as a function of age when the other explanatory variables are held at there means.) At the same time the timber stock increases from 115 cu.m/ha in the youngest age category to 139 cu.m/ha in the oldest age category of forest owners.

From figure 1c it can be seen that the young forest owners who harvest most also have the highest debts, and are therefore candidates for becoming rationed in the capital

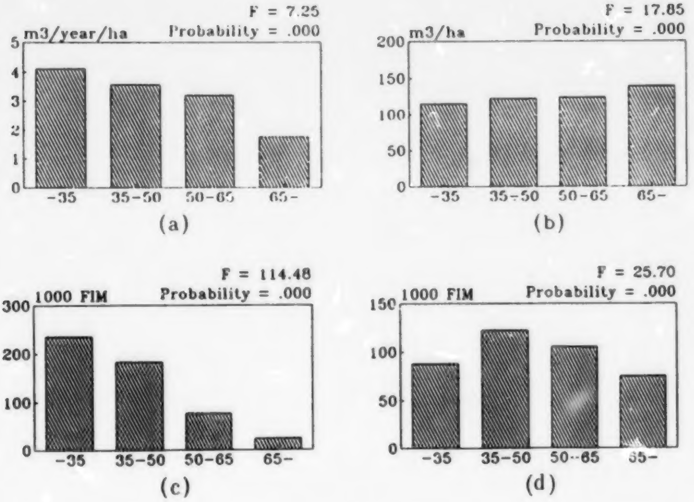

Figure 1. Average harvest (a), timber stock (b), bank loans (c) and nonforestry income of forest owners in different age categories.

market. Because nonforestry income, as given in figure 1d, is increasing during the initial period of the life cycle, young forest owners are also more likely to become borrowers initially than they would if the income profile was constant (Shah (1981)). However, towards the end of the life cycle, nonforestry income is decreasing. Nevertheless, the old forest owners harvest less than the young ones. Consequently, the low harvest of the old forest owners is not caused by replacing forestry income with increasing nonforestry income, as might be suggested.

The net worth of forest owners is positive in all age categories. The ratio of loans to real wealth decreases from 0.6 in the youngest age category to under 0.1 for forest owners over 65 years of age. Therefore, in the perfect capital market the NIPF owners of the sample should not have experienced any difficulties in obtaining bigger loans, which might have allowed them to follow a present–value maximizing harvesting policy. Hence, the empirical data seem to describe what might be called boundedly rational behaviour. Forest owners perceive credit rationing even when it does not exist, and/or agents in the capital market are unable to properly screen the credibility of their clients.

The average taxable wealth receives a negative sign in the linear regression model. This means that wealth can be interpreted as a proxy for expected income and it does not, somewhat counterintuitively, seem to be related to the NIPF owners' propensity to become rationed in the capital market. If the latter were the case, average taxable wealth should obtain a positive coefficient in the linear regression model explaining the timber stock (Kuuluvainen (1989)).

5 CONCLUSIONS

According to the results, the hypothesis of capital market imperfections, one possible reason for nonseparability of consumption and harvesting decisions, cannot be rejected in the Finnish case as the "preference" variables receive highly significant coefficients in the estimated timber supply equation. It is, of course, not possible to exclude the possibility that other market imperfections also affect the NIPF lands' timber supply. Still, life cycle harvesting and timber stock patterns, together with income and loan profiles, seem to point towards perceived credit rationing and boundedly rational timber supply behaviour. Even if the large variance in the per hectare harvest does not allow the use of the model for predicting individual harvest rates, the results help to understand the harvesting behaviour of NIPF owners. The results may also be useful in trying to predict future trends in aggregate timber supply, if the structure of ownership is expected to change and the market imperfections causing the nonseparability of consumption and harvesting decisions persist.

REFERENCES

BINKLEY, C. S. 1981. Timber Supply from Private Forests. Bulletin No 92. Yale University: School of Forestry and Environmental Studies. New Haven.

CARLÉN, O. 1986. The Swedish Private Non–Industrial Forest Owners' Cutting Behaviour – an Econometric Analysis Based on Cross–Section Data. Swedish University of Agricultural Sciences, Department of Forest Economics. Report 66.

JUDGE, G. G., HILL, R. C., GRIFFITHS, W. E., LUTKEPOHL, H., and LEE, T–C. 1985. Theory and Practice of Econometrics. John Wiley & Sons, New York.

JÄRVELÄINEN, V–P. 1981. Hakkuukäyttäytyminen yksityismetsälöillä. Summary: Cutting behaviour in the Finnish Private woodlots. Folia Forestalia 499.

JÄRVELÄINEN, V–P. 1988. Hakkuumahdollisuuksien käyttöön vaikuttavat tilakohtaiset tekijät maan länsi– ja itäosissa. Summary: Factors Affecting the Use of the Allowable Cut in Western and Eastern Parts of Finland. Folia Forestalia 707.

KARPPINEN, H. and HÄNNINEN, H. 1989. Yksityistilojen hakkuumahdollisuuksien käyttö. Summary: The Use of the Allowable Drain in Non–Industrial Private Woodlots. The Finnish Forest Research Institute. Folia For. Forthcoming.

KOSKELA, E. 1989. Forest Taxation and Timber Supply under Price Uncertainty: Credit Rationing in Capital Markets. For. Sci. 35/1, 160–172.

KUULUVAINEN, J. 1986. An Econometric Analysis of the Sawlog Market in Finland. Journal of World Forest Resource Management, 2: 1–19.

KUULUVAINEN, J. 1989. Nonindustrial Private Timber Supply and Credit Rationing. Microeconomic foundations with empirical evidence from the Finnish Case. Swedish University of Agricultural Sciences, Department of Forest Economics. Report 85.

KUULUVAINEN, J. 1990. Virtual Price Approach to Short–Term Timber Supply Under Credit Rationing. J. Env. Econ. and Manag. Forthcoming.

LOHMANDER, P. 1983. Optimal Harvest Policy under the Influence of Imperfections and Uncertainty. College of Forestry, Department of Forest Economics. Working Paper 22. Umeå.

LOIKKANEN, H. A., KUULUVAINEN, J. and SALO, J. 1986. Timber Supply of Private Nonindustrial Forest Owners. University of Helsinki, Department of Economics. Research Reports 50.

MADDALA, G. S. 1983. Limited–Dependent and Qualitative Variables in Econometrics. Cambridge University Press. Cambridge.

OLLIKAINEN, M. 1987. Timber Supply and Taxation under Price Uncertainty and Capital Market Imperfections (in Finnish). Licentiate thesis in economics. University of Helsinki.

OVASKAINEN, V. 1987. On Timber Supply Decisions under Liquidity Constraints and Project Indivisibility. A Theoretical Analysis and Empirical Test. A licentiate thesis. University of Helsinki, Department of Social Economics of Forestry.

SHAH, A. 1981. "Imperfections in the Capital Markets and Consumer Behaviour", Southern Economic Journal, 47 (4): 1032–1045.

TOBIN, J. 1967. Life Cycle Saving and Balanced Growth, in Ten Economic Studies in the Tradition of Irvin Fisher. W. Fellner (ed.). John Wiley & Sons, New York: 231–256.

TOBIN, J. 1972. Wealth, Liquidity and the Propensity to Consume, in Human Behaviour in Economic Affairs, Essays in Honor of George S. Katona. Strumpel, Morgan and Zahn (eds.). Elsevier, New York: 37–56.

YAARI, M. E. 1964. On Consumer's Lifetime Allocation Process. International Economic Review, 5 (3): 304–317.

FOREST DIE-BACK, GROWTH DECLINE AND TIMBER SUPPLY: AN ANALYTICAL MODEL

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FDC: 425.1: 425.3: 722.1

Forest die-back, or "novel" forest damage attributed to air pollutants, has become a major concern. The increased mortality of trees has been expected to increase timber supply in the short term through sanitation fellings. In the long term, acidification may result in a decline in soil productivity and sustainable harvest. Concerning the consequences to timber markets, however, little formal analysis exists.

In this study, the possible effects of pollution-induced forest damage on timber supply are explored theoretically using a two-period model of (a price-taking timber producer's) harvest timing and forest investment decisions. The impacts of environmental change are captured by two parameters in the growth function, representing (a) quality losses and decay resulting from increased mortality in the standing timber, and (b) an anticipated reduction in future soil productivity and growth.

According to the model, an anticipated growth decline tends to increase short-term supply (current harvest) through a timing effect, while the concurrent decay in standing timber reduces it (a scale effect). Thus, the net effect of increased pollution on short-term supply remains indeterminate *a priori*. The optimal management intensity is unambiguously decreased, since the future growth decline reduces the marginal return on forest investments *ceteris paribus*. Further, the short-term results are used while computing respective changes in long-term supply, defined as the discounted flow of timber from current and future harvests. The future growth decline affects long-term timber supply negatively through the decreased management intensity, while the long-term effect of harvest timing vanishes under plausible assumptions. As losses in standing timber contribute negatively, the total effect of increased pollution on long-term supply will be unambiguously negative.

Apart from the *ceteris paribus* results, market level consequences are discussed assuming that timber prices react to non-marginal shifts in supply. Especially where only a part of the forest area is subject to damage, price effects that arise will reduce the changes in aggregate harvest levels by affecting harvest timing in undamaged forests and attracting more intensive management. Price adjustments thus serve to make the forest-based sector less sensitive to external shocks. This is in line with scenarios which have suggested rather modest reactions in the timber markets under plausible degrees of forest damage.

A MODEL OF WOOD SUPPLY AND DEMAND IN THE UNITED KINGDOM

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FDC: 721.1--01: (41-4)

In the appraisal of future forest policy, it is necessary to have some idea about future supply and demand for wood. The last time a comprehensive study was carried out in the UK was in 1977, when the Wood Production Outlook was published. It was therefore, felt appropriate to update this work in 1989. This summarises the results so far from that work.

Future supply was estimated using traditional production forecasting techniques (ie yield models and rotation ages were applied to a forest inventory database to generate predictions of annual harvests). This was modified to include production from restocked crops, as the forecast was to go to the year 2050. To make this simple, it was assumed that crop type and yield would not change on restocking.

Future demand was estimated using econometric techniques. This involved building models to explain past demand based on a variety of macroeconomic variables. These were tested over the period 1956-86 for which data on wood product consumption were available. Twelve final products were identified and projections of demand for 11 of them (sleepers were left out) were made on the basis of projections of the macroeconomic variables.

The level of self-sufficiency in each of the final product categories was estimated based on the above models. This required future roundwood supply to be apportioned into different products, which could only partly be resolved by examining the data. Technical data such as conversion factors and the roundwood specifications for different products were of some help, but the split between products was based on relative output levels of the products in the past, and was essentially a best guess. This situation could be improved if the right input/output data were available.

The major demand predictions to 2000 and tentative projections to 2050 are given below. Self-sufficiency levels (in per cent) are given in parentheses. Self-sufficiency excludes production from imported roundwood and pulp. Paper is measured in '000 MT, else '000 m^3.

Product	1990	2000	2010	2020	2030	2040	2050
Coniferous sawnwood	8 177(17)	8 334(25)	8 392(41)	8 438(58)	8 487(64)	8 536(41)	8 585(29)
Non-coniferous sawnwood	1 251(32)	1 276(36)	1 285(32)	1 292(27)	1 300(25)	1 308(32)	1 316(36)
Newsprint	1 549(10)	1 684(14)	1 847(16)	2 040(15)	2 267(13)	2 527(8)	2 818(7)
Printing and writing	2 366(22)	3 157(23)	4 213(23)	5 621(18)	7 501(12)	10 009(6)	13 356(5)
Other paper	4 519(20)	4 990(26)	5 556(30)	6 229(28)	7 017(23)	7 923(14)	8 936(12)
Particleboard	2 538(75)	3 354(80)	4 336(82)	5 503(67)	6 871(50)	8 442(28)	10 199(22)
Plywood	1 050(5)	1 088(7)	1 101(11)	1 112(14)	1 124(16)	1 136(11)	1 147(8)

A longer version of this paper will appear in Forest Ecology and Management, published by Elsevier.

MEASUREMENT AND PREDICTION OF THE COMPARATIVE ADVANTAGE OF COUNTRIES IN THE INTERNATIONAL TRADE OF FOREST PRODUCTS

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SUMMARY

FDC: 722: 721.1

The Heckscher-Ohlin-Vanek theory predicts a relationship between the net trade of a country for a particular forest product, resource availability, and domestic demand. From this relationship, an index of comparative advantage was derived and computed for logs, sawnwood, wood-based panels, pulp, paper and paperboard. An empirical model of net trade was then estimated with international data from the 1960's and 1980's. The results showed that much of the differences in net trade could be explained by differences in wood availability, other resource endowements, and the level of domestic demand.

INTRODUCTION

This paper is a summary of a study of the performance of different countries in the international trade of forest products (see Bonnefoi and Buongiorno, 1990 for more details). The objective was to determine if differences in comparative advantage between countries could be explained by differences in resource endowment, especially the amount and type of forests, and by other characteristics of the countries, including domestic demand.

The study used the theory of international trade pioneered by Heckscher (1969), Ohlin (1963) and Vanek (1963), leading to a model that explains the net trade of a country as a function of its endowment in resources and its income. Countries were ranked with an index of comparative advantage derived from this theory. These rankings suggest natural groupings of countries in terms of resource availability, level of development and size of domestic markets. An empirical model of net trade was then estimated for different products with cross-section data from the early eighties and early sixties. The main findings were that comparative advantage in net trade of forest products could be explained to a large extent by endowments in forests and attendant resources, and by domestic demand. This relationship had improved between the early sixties and eighties.

MEASUREMENT OF COMPARATIVE ADVANTAGE

The link between net trade, prices, and ultimately resource endowment is provided by the theorem of Heckscher and Ohlin: a country tends to export commodities that use intensively the resources that are most abundant in that country, while it tends do import commodities that use relatively scarce factors (Kenen, 1985, p. 65).

A useful formalization of this idea can be found in Leamer (1984). In a country with balanced trade, net trade (exports minus imports), can be expressed as a direct positive linear function of the country's endowment in factors of production, and a negative linear function of the country's income. This equation can be rewritten to get the ratio of net trade to income, or RCA index. Thus, it implies a direct relationship between the RCA index of a country and its endowment in factors of production. The existence of such a relationship was explored for: Roundwood, sawnwood, panels, pulp, paper and paperboard, and their sum. Data were obtained for sixty three countries in the years 1984 to 1986 and averaged.

There were twenty-two countries with a positive RCA for total forest products trade Their primary common characteristic was a rich forest endowment. Yet, six of these countries (Finland, Portugal, Austria, Sweden, Yugoslavia, and Norway) were net importers of roundwood. Those six countries being all developed, suggests an influence of the level of development and of related domestic demand on competitive advantage.

Within the processed products, although some countries (Sweden, Finland, Portugal, and Brazil) had comparative advantage in all, most of them were more specialized. This specialization seemed to be strongly influenced by the level of development. The more capital-intensive the product, the fewer the developing countries with comparative advantage. Instead, comparative advantage in sawnwood and in panels was spread widely, which is consistent with the fact that these two products can be made with very different wood species, relatively unskilled labor and little capital.

The ten countries that did not have comparative advantage in pulp or paper (Congo, Cote d'Ivoire, Cameroon, Gabon, Malaysia, Philippines, Indonesia, Papua New Guinea, Burma, and Paraguay) were the least developed of the countries with overall comparative advantage in forest products trade. In addition to the skilled labor and capital requirements of the pulp and paper industries, the lack of pulping techniques for tropical species has also been a limiting factor for the development of these industries in developing countries that show comparative advantage in other sectors.

There were forty-one countries with negative RCA indices in total forest product trade, clustered in three sub-groups. The first one had fourteen developed countries (Japan, Belgium-Luxemburg, Australia, Switzerland, USA, Ireland, Denmark, Germany, France, Netherlands, UK, Italy, Spain, and Greece). They do have skilled labor and capital, implying that the reason for their negative net trade was a limited forest endowment relative to their large domestic demand.

In the second sub-group, were fourteen countries (Morocco, Syria, Iraq, Kuwait, Algeria, Tunisia, Iran, Saudi Arabia, Libya, Egypt, and Israel), all arid countries with little, if any forest. In addition, several of these countries also faced a strong demographic growth, and sometimes exceptional per-capita income from oil exports which led to increasing demand for wood products, unmatched by their rare and fledgling domestic industries.

The third sub-group consisted of the Latin American countries (Ecuador, Mexico, Colombia, Venezuela, Argentina, Trinidad and Tobago, and Cuba). The remaining countries

(Thailand, India, China, Turkey, Nigeria, Pakistan, Singapore, Korea Republic, and Hong-Kong) could hardly be classified at all. For most of them, and especially China, India, Nigeria, and Pakistan, a large population, leading to large domestic demand, is likely to be responsible for their low RCA indices.

In this group of countries with overall comparative disadvantage five developed countries (Australia, Denmark, Ireland, Switzerland, and USA) had comparative advantage in the roundwood trade only. Due probably to cheap labor abroad, these countries gave up some of the processing, exported roundwood, and imported processed products. Some other countries have specialized in specific processed products, taking advantage of favorable conditions. For instance, owing to their industrial dynamism and nearby roundwood supply, Singapore and Korea have achieved important comparative advantage in sawnwood and/or panels, Morocco, despite its limited forest resources, has developed a competitive pulp industry, based on eucalyptus plantations. Outstanding overall industrial performance has helped Japan to perform well in paper, in part using imported pulp. In Latin America, Ecuador distinguished itself by its comparative advantage in sawnwood and panels. In Europe, Belgium and Luxemburg did the same in panels. In fact, several countries that had a negative overall performance achieved competitive advantage in wood-based panels.

PREDICTING NET TRADE FROM COUNTRY CHARACTERISTICS

The Heckscher-Ohlin-Vanek theory implies a definite relationship between the comparative advantage of a country, its endowment in factors of production and its domestic demand. To test this hypothesis, we adopted Leamer's (1984) position that what matters in measuring resource endowment is the flow of goods and services that derive from the resources. Thus, the basic measure of forest endowment was the total volume of industrial wood harvested per year. Total wood production was also split into coniferous and non-coniferous, to test whether this would improve the predictive power of the theory. Income per capita was used as a measure of all factor endowments aside from forest resources that might affect comparative advantage.

This model, was estimated with data from sixty-three countries for the three-year average 1982 to 1984. The coefficient of determination ranged from 0.80 for total forest products trade, to 0.18 for roundwood trade. The coefficients of industrial roundwood and income had the expected signs and were significantly different from zero at the 0.01 significance level in all equations. Other things equal, wood availability did increase comparative advantage in net trade, while domestic demand decreased it.

The coefficient of income per capita was positive and significantly different from zero, at the 0.05 or 0.01 level, for total forest products trade, sawnwood, and paper. Thus, other endowments seemed to increase significantly the comparative advantage of countries. This was expected for paper, since the industry requires a substantial amount of capital and know-how, but not for sawmilling, which is widespread in developing countries.

Splitting roundwood availability into coniferous and non-coniferous improved the goodness of fit of the model for panels, pulp, and paper. The split also showed the importance of a particular species group for some products. For pulp and for paper, comparative advantage was related strongly to the availability of coniferous roundwood. For wood-based panels, the availability of both coniferous and non-coniferous roundwood influenced net trade, but the availability of non-coniferous roundwood seemed more important than that of coniferous species.

The model became quite useless in explaining net trade without the income variable to control for domestic demand. Not only did the fit become poor, but coefficients of endowment variables acquired negative and significant variables. This supports the Heckscher-Ohlin-Vanek theory embedded in Leamer's equations, which predict unequivocally a strong negative effect of domestic demand on net trade.

The model was estimated also with data for 1962 to 1964. The most striking difference was for roundwood, for which the model did not explain at all the net trade in the early sixties. Twenty years later, the equation explained 31 percent of the variation of net trade, with the wood availability and demand variables having the expected signs, and being statistically significant. This suggests that competitive market forces played a larger role in the early eighties; earlier factors, such as old colonial ties (Buongiorno *et al.*, 1980) had weakened.

For the other products, the results were similar for the early sixties and eighties. However, the effects of endowments other than wood, was significant only in the trade of paper in the early sixties. This effect had strengthened in the eighties and extended to other groups.

CONCLUSIONS

The Heckscher-Ohlin theory can be summarized by a set of of equations relating net trade to resource endowment and income. These equations lead to a simple index of revealed comparative advantage: the ratio of net trade to income. Using this index, countries were examined to assess their comparative advantage in the trade of forest products. Some natural groupings of countries were apparent, suggesting that comparative advantage arose in part from the availability of forest resources, the level of development, and domestic demand. This hypothesis was tested with an econometric model which, despite its simplicity, explained a large part of the variation in net trade for most commodity groups in the early eighties and sixties. Forest endowment had a strong positive effect on net trade. The explanatory power, was improved by distinguishing between coniferous and non-coniferous roundwood availability. Increases in income had a very strong, negative effect on net trade of all commodities, coherent with the theoretical effect of domestic demand. In fact, the net trade model was useless if demand effects were ignored. Endowment in other resources, reflected by income per capita, had a significant positive effect on the net trade of pulp, paper and sawnwood. This effect had increased from the early sixties to the early eighties.

ACKNOWLEDGEMENTS

The research reported in this paper was supported in part by the French Government, Ministry of Research and Technology, by McIntire-Stennis Grant 2855, and by the School of Natural Resources, University of Wisconsin, Madison. The work was done while B. Bonnefoi was on leave from the Ecole Nationale des Eaux et Forêts, Nancy.

REFERENCES

BONNEFOI, B., and J. BUONGIORNO, 1990. Comparative advantage of countries in the international trade of forest products. Forest Ecology and Management (forthcoming).

BUONGIORNO, J., P. TENNY, and J. K. GILLESS., 1980. Economic and political influences on international trade of tropical logs. Agricultural Systems 6:53-66.

HECKSCHER, E., 1949. the effects of foreign trade on the distribution of income. Economisk Tidskrift: 497-512. Reprinted as Chapter 13 in American Economic Association, Readings in the theory of international trade. Blakinston, Philadelphia.

KENEN, P., 1985. The international economy. Prentice-Hall, Englewood Cliffs, NJ. 552 p.

LEAMER, E. E., 1984. Sources for international comparative advantage: theory and evidence. MIT Press, Cambridge. 353 p.

OHLIN, B., 1967. Interregional and international trade. Revised Edition. Harvard University Press. Cambridge.

VANEK, J., 1963. The natural resources content of United States foreign trade, 1870-1955. M.I.T. Press, Cambridge.

SUPPLY OF AND DEMAND FOR SAWTIMBER AND PULPWOOD IN FINLAND

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The present study investigates the determination of the aggregate supply of and demand for sawtimber and pulpwood in Finland using annual data from 1961 to 1988. The econometric model for the Finnish roundwood market presented in Kuuluvainen et al. (1988) is extended and developed further. The sawtimber and pulpwood markets are assumed to be competitive and they are modelled separately. The demand equations are derived by assuming profit maximizing representative firms and the supply equations by assuming present value maximizing nonindustrial private forest owners. The study differs from Kuuluvainen et al. (1988) and from other roundwood market models presented in the literature, in that time series properties of the underlying data are examined in detail. In particular, the order of integration of time series and the cointegration between series using the so-called CRDW, DF and ADF-tests are examined. The properties of the time series are important in order that correct dynamic specification of the model can be selected and valid inferences from estimation results made. On the basis of the integration and cointegration tests, the validity of earlier results are discussed and alternative dynamic model specifications are proposed. Finally, estimation results from different model specifications are presented and compared.

Literature cited:

Kuuluvainen, J., Hetemäki, L., Ollonqvist, P., Ovaskainen, V., Pajuoja, H., Salo, J., Seppälä, H. and Tervo, M., 1988: The Finnish roundwood market: an econometric analysis. Finnish Economic Papers, vol. 1, no. 2, pp. 191-204.

ASSESSING STRUCTURAL DIFFERENCES BETWEEN OWNERSHIPS IN THE FOREST SECTOR

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Policy analysts in the United States have long discussed the disparity between investment levels on industrial and nonindustrial lands as cause for concern and policy action. Many programs have subsequently addressed the underproduction from nonindustrial forest lands as a partial solution to timber supply problems. Many causes have been proposed as reasons for lowered production on nonindustrial lands, among them a lack of profit motivation and the production and consumption of nontimber benefits from these lands. This paper examines and compares the production behavior of industrial and nonindustrial forest landowners using a profit function framework. This approach allows comparing the behavior of the two ownerships and testing for differences as well as examining an implicit valuation of standing trees -- an estimate of the valuation of forests for both timber and nontimber uses.

The profit function models production behavior of forestland owners in terms of their responses to varying input and output prices. Given a wide enough variation in prices, the profit function can be used to define the efficient combination of inputs and outputs and therefore the forestry production technology. That is, profit and production functions are dual models. The approach also allows the inclusion of constraints on the responses of producers. For example, juvenile trees cannot be converted into solidwood products. Also, the land available for timber production in one period is limited by the profitability of different land uses.

For this case we assume that landowners alter their harvesting and regeneration plans in response to input and output prices but contingent on the amount of their inventory which can be harvested. In addition, we assume that forest land is not entirely freely disposable in the short-run. Profit (P) is therefore modeled as a function of product and regeneration prices (vector p) as well as land (L) and growing stock (G) levels:

$$P = g\ (p, L, G)$$

This modeling frame also allows for a distinction between production opportunities in the short and in the long-runs. In the short-run, the variable outputs (sawtimber and pulpwood) and variable inputs (regeneration effort) can adjust in response to price changes but are contingent on fixed levels of the other inputs (land and growing stocks). In the long-run, these other inputs may also adjust. Given information on the value of these other inputs, the potential for long-run response can be derived from the short-run model.

This formulation assumes that a similar age-class distribution holds across our observations so that aggregate levels of growing stocks can serve as a proxy for harvest potential. For example assuming an approximately "normal" forest would imply that the same portion of growing stocks could potentially be harvested in any given period. This assumption appears generally tenable for our region of study: the Southeastern Coastal Plain of the United States. This area has one of the most productive managed forests in the world and serves as a good region to demonstrate our methods. Cross-sectional data on harvesting and regeneration were merged with regeneration cost and product prices to define the profit function and output supply/input demand equation system. This system was then estimated using methods which account for its error structure and elasticities were developed from these estimates.

Two dominant results emerge from the analysis. First, the estimation results show the two ownership types to behave in strikingly similar manners with respect to their responsiveness to input and output price changes both in the short-run as well as the long-run. Differences in their levels of production are explained by apparently reasonable differences in the valuation of standing tress, reflecting a higher valuation of nontimber uses for the nonindustrial group. Therefore, it may be unnecessary to separate the two ownership groups in forest sector models. Second while the short-run stumpage price responsiveness for both ownerships and products is quite low (ranging between 0.0 and 0.5), the long-run elasticities are very large (between 2.2 and 3.5). This indicates that those making price projections must be very careful in depicting the effects of price on supply as short-run effects do not correspond to what will occur in the long-run.

We also examine the estimated profit function for the conditions of profit maximizing behavior in a competitive market. We can reject profit maximization for neither ownership. In addition, estimates were used to test the hypothesis that the behavior of both ownerships could be explained by the same production model. This hypothesis cannot be rejected, indicating that, for our region, the behavior of nonindustrial owners is consistent with industrial owners. What is apparent from our analysis is that nonindustrial owners value their standing timber resource quite differently than do industrial owners, while at the same time responding to market prices as profit maximizing economic agents.

THE SUPPLY OF CANADIAN TIMBER IN RELATION TO DEMAND

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SUMMARY

Canada has a rich and varied forest resource base, embracing high quality timber and non-timber values. Nevertheless, our forests are not inexhaustible. The production of high quality coniferous sawlogs has now reached and in some cases surpassed the sustainable level. A visionary strategic plan is called for, with supportive action in the form of intensive forestry, closer utilization, and a better balance in terms of integrated resource management. A major improvement in attitudes, policies and programs will be needed to ensure that Canada's forest destiny is achieved.

Key words: timber supply, intensive forestry, strategic planning

INTRODUCTION

Investors in the forest products industry of Canada are beginning to focus with increasing alarm on timber supply constraints. The current recognition of raw material shortages is in sharp contrast to the situation a decade or more ago. The myth of an inexhaustible forest was widespread in the general population and all too common in the board rooms of industry and finance. That complacency has now vanished.

The primary objective of this paper is to provide a synopsis of Canadian timber supplies, together with an estimate of the availability of industrial roundwood in the next couple of decades. The adequacy of supply depends to an increasing degree on environmental constraints, as well as on the more recent practice of re-allocating portions of forest licences for non-industrial purposes such as wilderness. Then we will turn to the options open to our land managers. There are means at our disposal to mitigate at least in part the threatened curtailments and to provide in the longer run for further expansion.

BACKGROUND

By a number of measures, Canada ranks as the world's No. 1 forestry nation. In historic terms, our economy relied on the forest resource as the basis of early commercial and industrial development. This record rests on the fact that about two thirds of the combined area of the 10 provinces is classified as forested. Canada embraces one tenth of the world's forests. The forest is the source of employment for approximately one million wage earners, directly and indirectly, the largest of any industry in Canada. The selling value of shipments exceeded $41 billion dollars in 1989 and exports of these forest products amounted to $23 billion. Our forest products exports to the US alone were some $15 billion.

Canada is the dominant exporter of three important commodities: newsprint, softwood lumber and wood pulp. In further manufactured forest products, however, we rank behind Finland, West Germany, and Sweden in that order. Norway, Sweden and Finland combined are strong competitors, matching our 23 per cent share of world markets for manufactured forest products and far outstripping us in the higher valued printing, writing and converted paper categories. Canada accounts for only 5 per cent of world exports of other paper and paperboard, compared to 30 per cent for Scandinavia.

TIMBER SUPPLY

For the purposes of this analysis, we will ignore those forests above 60 degrees, which are valued primarily as protection for the general ecosystem and the wildlife food chain, and concentrate on the resources within provincial boundaries. Every province has an important stake in forestry. Ownership of this forest is 90 per cent provincial, slightly under 8 per cent is private, and 2 per cent is federal. However, it is important to note that private ownership predominates in some provinces and regions.

Only three-fourths of the forests are *productive* or capable of bearing a merchantable harvest in a reasonable time. This classification by productivity is just the beginning of a netting down process necessary to derive an estimate of the forest land available and suitable for industrial use. Of the productive forest, one hectare in nine is not stocked with a commercial crop of trees, a condition resulting from failure to regenerate promptly following harvest or after natural depletion by fire, insects and disease. Parks and wilderness areas now account for over 6 per cent of all land in B.C., or an area nearly as large as New Brunswick, and a share slightly above the national average.

There are other important reductions in the productive forest due to environmental and logging guidelines which effectively set aside around one fifth of the forest land. This excludes fragile sites, steep slopes, higher elevations which are not easily regenerated, stream bank protection, and landscape logging adjacent to highways. In addition, there are large forest areas which are rendered economically inaccessible by reason of remoteness, high logging costs, low volumes per hectare, or less attractive species. For example, the Ministry of Forests in British Columbia calculates that less than 40 per cent of the province's forest land is presently classed as productive, available and suitable for industrial timber harvesting.

Species mix is another key determinant of timber values. Canada has an international reputation for those high quality coniferous species which make up 72 per cent of our merchantable timber volume. Mixedwood stands amount to 18 per cent and the remaining 10 per cent is classified as deciduous. The latter are mainly aspen/poplar types that are relatively abundant compared to available markets. The more valuable high density hardwoods were depleted several decades ago.

During the late 1970's the aggregate permissible harvest, what is called the annual allowable cut or AAC, was estimated to be 256 million m^3, a figure reported in Forest Management in Canada (Reed 1978). This amount was reduced to 228 million m^3 in "A Forest Sector Strategy for Canada" (Canadian Forestry Service 1981). More recent surveys suggest a further reduction to 204 million m^3 (Reed 1986). Some 81 per cent of this is coniferous. The main reasons for successively lowering the AAC are past neglect of forest renewal, heavier than expected losses from fire and insects, the establishment of parks, wilderness and other reservations, and the application of environmental guidelines to logging. A less obvious factor is the failure to distinguish between the physical volume of timber on the one hand and its quality or economic accessibility on the other. Another issue is the quality of forest renewal. The past regeneration success rates are not encouraging. Successful regeneration, by natural re-seeding and planting, still fell short of the total area harvested by approximately one quarter in 1985-86 (Kuhnke 1989). Some progress has been made since in closing the gap but we ought to be spending more than the $800 million now applied to silviculture. In my view, the amount should be $1 billion or more annually and we should be spending it more effectively.

Assuming that reductions in the AAC are imminent, for the reasons described above, is there any way these can be offset by intensifying forest management? Fortunately, there is a possibility in many cases to capture what is known as the *allowable cut effect*. This term means that when the next crop is managed so as to mature earlier, then the old growth does not have to be stretched out for such a long period. One way to look at the forest is to assume that each stand of timber is in a queue moving toward harvesting. Intensive silviculture treatments can bring these forward in time.

However, bringing the harvest forward in time is only the first benefit. Intensive forestry also means higher volumes per hectare, more uniform tree size, lower logging and milling costs, higher sales realization values when the products are sold, and a reduction in operating risk.

TIMBER HARVEST

Will there be enough trees in Canada to satisfy the future needs of our present industrial capacity, and perhaps allow for modest growth? A first approximation of the answer can be found by comparing the AAC with the trend in roundwood harvest. For conifers, the AAC of 166 million m^3 compares with the combined provincial harvest of 175 million m^3 in 1987. In the case of deciduous, the allowable cut is three times the 1987 harvest of 12 million m^3. A few brief interpretive comments will be useful to indicate regional differences.

The British Columbia timber harvest reached an all time high of 91 million m^3 in 1987, compared to an AAC of 75 million m^3. This allowable cut is projected to begin a steady decline within the next 20 years, according to estimates made by the province (Ministry of Forests, 1984). The forest resource in B.C. is over-committed, given the present expenditures on forestry. Plans to correct this have not yet been crystallized, although some improvement is certainly feasible if an effort is made.

Alberta is one province where a realistic AAC is above the harvest level. This is reflected in the current investment program which could nearly double industry capacity by 1993. Moreover, an upward revision of the coniferous AAC is likely to be made, based on areas of near-mature forests which are expected to reach merchantable age soon after the end of the century. This would open up a further expansion potential. Both Saskatchewan and Manitoba are boosting manufacturing capacity and appear to be nearing a production plateau that will absorb most of their estimated coniferous surplus of AAC over harvest.

Ontario is more difficult to assess. They show on paper a surplus of coniferous AAC over harvest, but there has been relatively little new capacity built in the last 25 years. Some observers suspect that a reduction in the AAC is overdue, because of the scarcity of second growth forests within easy distance of the mills, disappointing regeneration performance, heavy losses of mature timber to insects, and a large supply of over-mature timber which is difficult to harvest and convert at a profit. Painful curtailments in the sawmill industry have already begun, and these suggest that sawlog supplies have been run down to a danger level.

Quebec has just completed a major forestry policy and planning exercise which scales down expectations and places a more realistic set of forest management goals in front of the forest community. Quebec suffers also from over-commitment of the higher quality southern forest. They are at historic roundwood production levels and further expansion will be difficult to achieve, if indeed they can continue to supply this volume of roundwood to existing industry at a competitive cost. Quebec imports about 3 million m^3 of softwood annually from neighboring provinces and states, a majority of which is sawlog quality.

The four Atlantic provinces taken as a group are facing possible curtailment of harvesting. New Brunswick has less timber available than is needed by its manufacturing plants when operating at full capacity. Nova Scotia has identified a coniferous deficit around the year 2005. Newfoundland's forest is fully committed with three newsprint mills in operation, and may even face a deficit within a decade if some way is not found to offset major insect losses suffered since 1970. Prince Edward Island is endeavoring to rehabilitate its farm woodlot resource, a job which will obviously take some time.

On balance, Canada will never run out of trees. The more sensible question is whether we have an assured supply of industrial softwood which can be delivered to the mills at a competitive cost. Clearly there are deficits in economic terms already, and in every region. These are expressed initially in a shortage of prime sawlogs and there seems to be little hope that Canada can avoid a reduction of sawn lumber output of at least 10 per cent over the next decade or so, given the silviculture funding now in place.

Less needs to be said about the Canadian deciduous timber supply. The aggregate AAC in the 10 provinces is around 38 million m^3 and the annual harvest is now 12 million m^3. The constraint here is not on the supply side but on markets, the adoption of new technology and new product development.

IMPLICATIONS

To recapitulate the foregoing analysis, I have identified five implications. First, the Canadian production of softwood products is now constrained by a relative shortage of timber which can be delivered to mills at a competitive cost. This is driving up stumpage on public timber. Second, sawlog shortages will become pervasive in the 1990's. Third, this also means that sharply higher prices are in store, which in turn raises the specter of substitute materials.

The fourth implication is that pressure from wilderness, recreation and environmental groups will remove large areas of mature timber from existing licenses. Something inventive must be done to break this impasse in land use disputes. Fifth, all parties interested in forest land use would benefit by broadening their horizons. Realism demands that the strategic planning process not only be strengthened, but that equal weight be given to timber and non-timber values alike. Having taken this step, it is much easier to affirm the principle of Conservation and Wise Use.

CANADIAN RESPONSE

Canada's historic performance as a competitor has been relatively successful. Coniferous output grew from 80 million m^3 in 1960 to the current level of 175 million m^3 in 30 years, or by 2.6 per cent per year. The best we can expect for the next two decades is to plateau around the present harvest, given both closer utilization and more intensive forestry. This means giving up world market share at a time when consumption is increasing at 1-2 per cent annually.

An appropriate Canadian response to these timber supply problems can be visualized, as a package of forest management strategies. It is imperative that these be prepared as an urgent matter of business. In my view we should set strategic growth goals for coniferous roundwood production of at least 225 million m^3 for the year 2020. That is only 30 per cent above today's level and quite modest in relation to growing market opportunities. In the short term, there are other government policies to re-assess, such as trade in logs and pulpwood chips.

Industry will have a somewhat different set of timber deficit balancing factors for example: intensive silviculture, reduction in logging waste, commercial thinning, increased recycling, and greater utilization of deciduous species. This will involve large outlays for capital equipment and will usually increase operating costs. There may be some comfort in the fact that our competitors are facing similar problems, and their adjustment process will probably parallel our own.

The extent to which we succeed in achieving our destiny in forestry will depend on how resource issues are dealt with in the next few years. I say a few years because in many communities the process of forest depletion is already well advanced. We must act quickly on forest renewal and timber stand improvement if we are to forestall serious dislocation in the forest sector.

LITERATURE CITED

Canadian Forestry Service. 1981. A forest sector strategy for Canada. Ottawa. 26pp.

Kuhnke, D.H. 1989. Silviculture statistics for Canada: An 11-year summary. Forestry Canada, Edmonton. 81pp.

Ministry of Forests. 1984. Forest and range resource analysis. Victoria. 450pp.

Reed, F.L.C. 1978. Forest management in Canada. Vol. I. Canadian Forestry Service, Ottawa. 155pp.

Reed, F.L.C. 1986. Canada's timber supply. For. Chron. 62:335-338.

MODELLING NEWSPRINT DEMAND:

A CASE STUDY OF FINLAND

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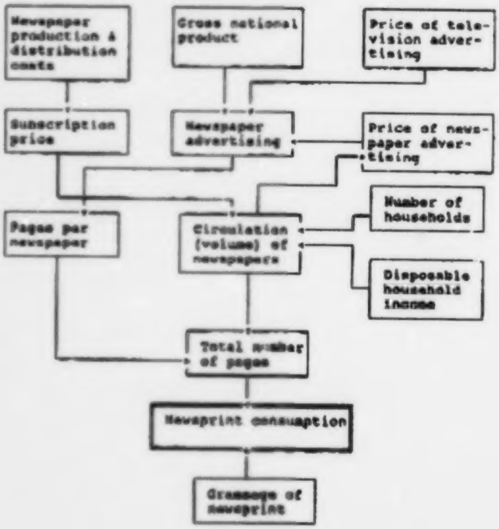
Most newsprint demand studies have analyzed demand in isolation from the actual consumers of newsprint, i.e. from the newspaper industry. Consequently, factors affecting the development in the newspaper industry have received only scant attention.

To analyze factors affecting newsprint demand in Finland (in 1960-1986) a recursive multiequation model was constructed and estimated to describe the newspaper industry and to obtain information on casual factors influencing newsprint consumption emphasis being on the decision-making process and the timing of decisions in purchasing newsprint and newspapers. The basic structure of the model is presented in the figure.


Newspaper production & distribution costs
Gross national product
Price of television advertising
Subscription price
Newspaper advertising
Price of newspaper advertising
Number of households
Pages per newspaper
Circulation (volume) of newspapers
Disposable household income
Total number of pages
Newsprint consumption
Grammage of newsprint

Model Structure for Newsprint Demand

The individual equations in the model system performed well, but the model as a whole underestimated newsprint consumption. The main forces influencing newsprint consumption were found to be 1) total circulation of newspapers that is mainly dependent on the rate of household formation, 2) volume of newspaper advertising that depends on the level of general economic activity, and 3) the development of newsprint grammage (exogenous to the model).

TROPICAL-TEMPERATE
SAWLOG SUBSTITUTION IN JAPAN

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SUMMARY

Japan imports sawlogs primarily from three regions: North America, the Soviet Union, and the South Seas. Imports from North America and the Soviet Union are mainly temperate softwoods, while imports from the South Seas are mainly tropical hardwoods. During 1970-87, the North American import share (based on quantity) rose 50 percent, the Soviet share was constant, and the South Seas share fell 50 percent. This paper develops a multi-output profit function framework to analyze these changing import patterns. The framework permits testing whether import demands have been significantly affected by relative *net* prices (the difference between lumber price and cost of log input per unit of lumber), adjustment lags, structural change, and technical change. Econometric results indicate that all these factors were significant during 1970-87. Sawlogs from the three regions were substitutes for each other, with cross-net-price elasticities between temperate and tropical categories increasing over time. These findings suggest that deforestation-induced scarcity of tropical hardwoods will lead to increased demand for temperate softwoods, and that current forest-sector models, which do not treat hardwoods and softwoods as substitutes, fail to capture an important feature of global trade in forest products.

Key words: Tropical timber, international trade, timber demand, Japan, South Seas

INTRODUCTION

Japan is the world's most important log importer. Three regions supply 95 percent of its total log imports: North America, the Soviet Union, and the South Seas. Imports from North America and the Soviet Union are mainly temperate softwoods, while imports from the South Seas are mainly tropical hardwoods. Virtually all of the North American and Soviet logs, but a much smaller proportion of those from the South Seas, are sawlogs. Imports comprise more than half of Japanese sawlog consumption.

Japan has recently been criticized by international environmental organizations for contributing to tropical deforestation by importing South Seas logs. Some organizations have suggested that Japan shift its consumption toward logs from temperate regions. Japan appears to have done this in the case of sawlogs: during 1970-87, the North American import share (based on quantity) rose 50 percent, the Soviet share was constant, and the South Seas share fell 50 percent.

What has caused these trends in Japanese sawlog imports? Can they be expected to continue? If so, not only will pressure on tropical timber resources slacken, but opportunities for marketing temperate logs in Japan will expand.

A THEORETICAL MODEL OF IMPORT DEMAND FOR SAWLOGS

Key features of the theoretical approach developed below are that sawlogs imported from different regions are permitted to be imperfect substitutes, that substitution is governed by *net* sawnwood prices, and that sawlog demand need not adjust instantaneously to long-run equilibrium levels.

The sawnwood industry's profit function reflects the profit-maximizing combination of products and factors at given prices:

$$\pi = \pi(P,p,w). \tag{1}$$

π is total profits, P is a vector of product prices, p is a vector of sawlog prices, and w is a vector of prices of other factors. There are m categories of sawlogs ($p = p_1,\ldots,p_m$), corresponding to regions of origin, with one aggregate product made from each category. Hence, there are m products as well.

The profit function given by Eq. 1 can be represented in a more convenient form for studying sawlog substitution if sawlogs are assumed to be "weakly separable" from other factors. The assumption of weak separability permits analysis of a simpler function, $\pi^p = \pi^p(P,p)$, which reflects the combination of products and sawlogs that solves the following problem:

$$\max_{Q_i,q_i} \{ \sum_{i=1}^{m} P_iQ_i - \sum_{i=1}^{m} p_iq_i \}. \tag{2}$$

Q_i is output of each product and q_i is sawlog consumption.

Forest sector models have typically assumed that sawlogs are converted to products by a fixed-factor, or Leontief, process:

$$Q = aq. \tag{3}$$

a is the recovery rate. The fixed-factor assumption allows us to replace P and p in π^p by net sawnwood prices:

$$P^n = P - p/\alpha. \tag{4}$$

Demand equations for sawlogs from region i can be derived from π^p by Hotelling's lemma:

$$q_i^* = \frac{\partial \pi^p}{\partial p_i} = \frac{\partial \pi^p}{\partial P^n_i} \frac{\partial P^n_i}{\partial p_i} = - \frac{\partial \pi^p}{\partial P^n_i} \frac{1}{\alpha} . \tag{5}$$

The asterisk (*) indicates that q_i^* represents a long-run equilibrium level of consumption. Adjustment lags, which prevent sawlog consumption from adjusting instantaneously to the desired long-run level, can be modeled by a partial adjustment process that relates observed to desired changes in consumption from period to period:

$$q_i - q_i(-1) = \theta_i[q_i^* - q_i(-1)], \tag{6}$$

where $0 \leq \theta_i \leq 1$.

METHODS

The empirical model was a system of three demand equations for sawlogs imported from North America, the Soviet Union, and the South Seas. Demand for domestic (Japanese) sawlogs was not included, due to fundamental differences between domestic- and import-based sawmills in Japan. The demand equations were derived from a multi-output, generalized Leontief profit function and were given by:

$$q_i = (1 - \theta_i)q_i(-1) + \theta_i[\sum_{j=1}^{m} \beta_{ij}(P^n_j/P^n_i)^{\frac{1}{2}} + \beta_{it}t\ ]/\alpha_i. \tag{7}$$

β_{ij} and β_{it} are parameters. $\beta_{ij} = \beta_{ji}$, for $i \neq j$. If $\beta_{ij} < 0$, sawlogs from regions i and j are substitutes; if $\beta_{ij} > 0$, they are complements. "Technical change" (strictly speaking, an unexplained residual trend) is biased toward the use of sawlogs from region i if $\beta_{it} > 0$, and against if $\beta_{it} < 0$.

Cross-net-price elasticities are given by:

$$\epsilon_{ij} \equiv \frac{\partial q_i}{\partial P^n_j} \frac{P^n_j}{q_i} = \theta_i\beta_{ij}(P^n_j/P^n_i)^{\frac{1}{2}}/(\alpha_i q_i). \tag{8}$$

Long-run values are determined by setting $\theta_i = 1$. Eq. 7 is homogeneous of degree zero in net prices, so the own-net-price elasticity for sawlogs from region i is given by:

$$\epsilon_{ii} = -\sum_{j \neq i} \epsilon_{ij}. \tag{9}$$

Annual data on Japanese sawlog imports during 1970-87 were used to estimate the model. Consumption of sawlogs was measured in thousand cubic meters, and prices were measured in nominal yen per cubic meter. The three equations were estimated jointly since they include shared parameters. A multivariate maximum-likelihood technique (essentially, iterative nonlinear seemingly unrelated regression), which allowed nonzero error covariances across equations, was employed.

Five variants of the model were estimated. The unconstrained model (Model I) corresponded to Eq. 7 with an additional allowance for structural change in the β_{ij} parameters between the first and second halves of the estimation period. In Model II, adjustment lags were excluded; in Model III, technical change was excluded; in Model IV, structural change was excluded; and in Model V, both technical change and structural change were excluded. Likelihood ratio tests were used to test whether Models II-V were significantly different from Model I.

RESULTS

The likelihood ratio tests indicated that Models II-V were all significantly different from Model I at the 5-percent level. This means that adjustment lags, technical change, and structural change were statistically significant during 1970-87. Adjustment coefficients were significantly different from both 0 and 1 in all regions. The only evidence of technical change was a negative trend for imports of South Seas logs.

Table 1 presents long-run net-price elasticities:

Table 1. Long-run net-price elasticities

		Net lumber price		
Region	Period	N. Am.	U.S.S.R.	S. Seas
N. Am.	1971-78	0.65	-0.12	-0.53
	1979-87	0.85	-0.07	-0.78
U.S.S.R.	1971-78	-0.16	0.22	-0.06
	1979-87	-0.13	0.55	-0.42
S. Seas	1971-78	-0.19	-0.02	0.21
	1979-87	-0.45	-0.14	0.59

Long-run demands were inelastic with respect to both cross- and own-net prices. All cross-net-price elasticities were negative, indicating that sawlogs from the three regions were substitutes. Cross-net-price elasticities were generally smaller between North American and Soviet categories than between South Seas and either temperate category. Structural change caused own-net-price elasticities, and cross-net-price elasticities between temperate and tropical categories, to increase between the two periods. This suggests an increasingly competitive Japanese sawlog market in which temperate-tropical substitution is increasingly price sensitive.

DISCUSSION

The econometric analysis detected strong evidence of increasing substitutability between tropical and temperate sawlogs in Japan during 1970-87. Although adjustment lags dampened short-run responses to price changes, long-run cross-net-price elasticities between tropical and temperate categories were significant and increasing. Moreover, technical change accelerated the movement away from tropical logs.

The negative technical change for South Seas sawlogs is more an observation than an explanation. Perhaps the most likely explanation for this residual trend is a strategic effort by the sawnwood industry to broaden its log sourcing out of concern over future supply of South Seas logs.

The evidence of tropical-temperate substitution is interesting in light of our previous failure to detect evidence of substitution between well-known and lesser-known tropical species (Vincent *et al.* in press). The Japanese sawnwood industry appears to have decided to shift toward temperate timbers, rather than from one type of tropical timber to another.

The analysis in this paper pertains only to sawlogs. Since imports of veneer logs from the South Seas are far greater than imports of South Seas sawlogs, it would be interesting to replicate the analysis for the plywood industry in Japan.

Most forest-sector models used for forecasting or policy analysis do not treat hardwood and softwood products as substitutes in either production or consumption. The apparent tropical hardwood-temperate softwood substitution that has occurred in Japan in recent decades suggests that this rigidity may cause these models to fail to capture an important feature of the global forest sector.

LITERATURE CITED

Vincent, J.R., Gandapur, A.K., and Brooks, D.J., in press: Species substitution and tropical log imports by Japan. *Forest Science*.

December 12, 1989

LOCAL ACTION PROGRAMS TO CREATE JOB OPPORTUNITIES IN FORESTRY

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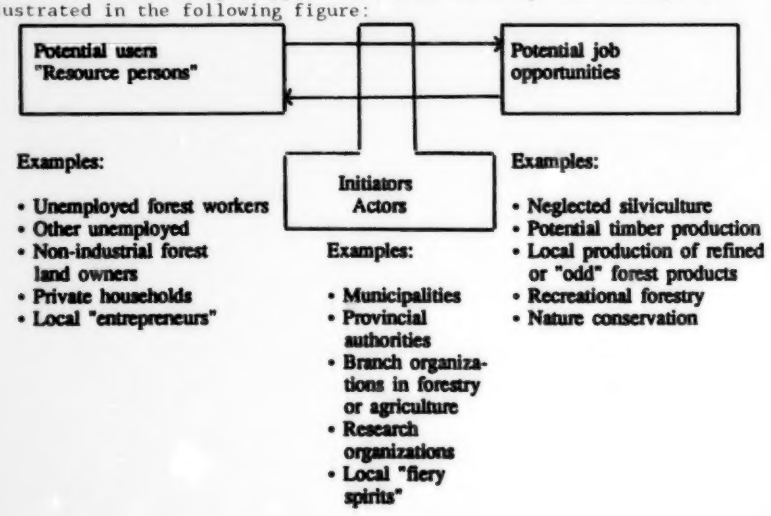
In the beginning of the eighties in Sweden, a number of action programs were initiated to create job opportunities by means of intensified use of the forest resource. Comparatively high unemployment was the main cause. The programs were primarily initiated by municipalities. At the Faculty of Forestry, a group of researchers studied this problem area. Active participation in action programs was one way, program evaluation another. We got deeply involved in three municipal programs, which we have evaluated (Ager and Engsds 1990). We have also tried to review all action programs carried out in Sweden in the 80s which were connected with forestry (Burell, Hillring and Lidestav 1990).

The definition of a local action program in this context is the effort (of an actor) to identify, mobilize and link together "resource persons" (potential users) and job opportunities in forestry. The concept is illustrated in the following figure:


Potential users
"Resource persons"
Potential job opportunities
Initiators
Actors
Examples:
• Unemployed forest workers
• Other unemployed
• Non-industrial forest land owners
• Private households
• Local "entrepreneurs"
Examples:
• Municipalities
• Provincial authorities
• Branch organizations in forestry or agriculture
• Research organizations
• Local "fiery spirits"
Examples:
• Neglected silviculture
• Potential timber production
• Local production of refined or "odd" forest products
• Recreational forestry
• Nature conservation

For systematic description and evaluation, a model of an action program has been formulated. The evaluation model rests upon some basic conditions for success of a program, formulated as a basic "theory" for the programs. The hypotheses have been used to facilitate interpretations, especially to distinguish between theory failure and program failure.

Some expiencies from the action programs will be summarized here.

A thorough analysis of the problems and clearly expressed objectives is a good start to a successful program. Objectives have to be realistic, especially as far as the duration is concerned. Many projects take several years to realize.

The identitication of appropriate "resource persons" is crucial. The categories can vary considerably with the variation of the economic situation of a country.

In Sweden, the greatest potential for new job opportunities can be found within the private (non-industrial) forestry sector. The recent development of appropriate technology for small woodlots strengthens this potential.

A "local motor" - a person with motivation, authority, contacts etc - can be the key to success of an action program.

There are a number of means to be used in an action program. Education, advice, information and demonstration have been found to be relatively successful.

In the evaluation of the effects of a program it is important to consider also qualitative aspects of new job opportunities, not just the number of jobs. The effects of the new jobs on the social system of the local society is one qualitative aspect, the attractiveness of the individual job opportunity another.

Keywords: Rural development, forestry, action research

LITERATURE CITED

Ager, B. and Engsas, J., 1990: Nya arbetstillfallen genom lokala skogliga aktionsprojekt. New job opportunities through local action projects in forestry. Swedish University of Agricultural Sciences, Department of Operational Efficiency. Report No 186. Garpenberg. In Swedish with an English summary.

Burell, U., Hillring, B. and Lidestav, G., 1990: Kartlaggning av projekt for intensivare skogsbruk och landsbygdsutveckling. Review of projects for intensified forestry and rural development. Swedish University of Agricultural Sciences. Department of Operational Efficiency. Uppsatser och Resultat No 165. Garpenberg. In Swedish with an English summary.

THE ESTABLISHMENT OF MUNICIPAL WOOD-BASED FUEL PRODUCTION

FOCUSING THE VALUE OF LOCAL EMPLOYMENT

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INTRODUCTION

The Swedish legislation has since the seventies delegated more and more responsibility to the municipalities to carry out an overall covering plan for supplied and used energy inside the own territory (1). This task coincides with the fact that many other areas of official planning have been moved from central to local or regional liability. The policy for regional economic affairs has left the method of detailed and enterpriseoriented support for a more generalized economic policy and intrastructural support with regional considerations.

Thus the changes makes it possible to arrive at more "egoistical" decisions on the municipal level. Expressed in another way you can say that the formal all-over valid sector-rules decided on the national level have weakened for the benefit of locally adapted cross-sector decisions.

In recent literature on the topic of local energyplanning one can follow this course of development. You suggest for instance that the municipality may choose a more expensive district heating-system for environmental-, reliability- or other locally dependent reasons. But the extra cost in this case has to be payed by all inhabitants and not just by the heat-subscribers (1).

There is also a discussion on a principal level that the municipalities are parts of the nation in the same way as the nation is a part of the world. And just because of that it is not self-evident that the welfare of the members of the municipality coincides with the welfare of the members of the nation (2).

In the recent official analysis of the regional policy on government level one also suggests a benefit of breaking down the national accounts to a regional level in order to better understand the causal connection between the qualities and the economic growth of the region (4).

Inside the institutional framework mentioned above, local decisions on investment in wood-based heating systems on a local cross-sector optimizing basis ought to be based on a business calculation completed with a local analysis of the consequences of the national policies for energy, regional development, agriculture and forestry. Relevant dimensions for the consequences are of course very dependent on the local conditions. For rural districts the dimension of labourmarket always is of great interest.

Today the policies for these areas are characterized as follows:

* Energy: all nuclear power production will be shut down in the year of 2010. The starting point for this change will be in the middle of the nineties. Great uncertainty on the local level on future prices and supply of different kinds of energy sources. In this respect bioenergy seems to be one of the most predictable. Actual tax- and environmental legislation will in a general way raise the competitiveness of bioenergy and natural gas. For the largest municipal energy investments, that is district heating plants and cogeneration plants for heat and electricity, these two fuels probably will be the most common as far as small and middle sized constructions are concerned.
Of these two, natural gas will be the cheapest one in the case where the gas pipe-system passes in the neighbourhood. The feature and extension of the system is not yet decided in detail and that will cause a delay in many investment decisions.

* Regional development: Apart from good or bad trends of the national economic situation the pull and push towards greater urbanization and interregional unbalances is still to be expected. Concerning the intitutional framework it ought to be more and more common in the future to see locally specified and politically anchored strategies for development. On a scale from a maximum of adaption of the local resources to the demands of the market in the postindustrial centers to pure survival strategies in some rural and distant municipalities. In the latter you will see elements of local macro-economic judgements of the alternative costs of the labourforce (3)(5)(6)(7).

* Agriculture: The development of the production techniques and the coming disregulation of the market for agricultural products will end up in a surplus of production area of say 20-30% of the total (500000-900000 ha).

* Forestry: There is an expanding world market for forest industrial products. The country has a considerable potential for a raise of the annual cut. In the next 10-15 years you will find about 80% of this potential in the private woodlot-owners forests. (There are about 240000 private woodlot-owners and their forests constitute 50% of the total of forest land).

PROJECT PROPOSAL

Concerning this background we intend to start a project with the purpose to identify, describe and quantify the local demand for labour force and the local value added in connection with the employment (the calculated local alternative cost of the employees) when establishing municipal wood-based fuel production. The project wig considerate fluctuations in the general economic situation and take into account the local differences in commercial and industrial life, the structure of agriculture and forestry, market for "exporting" wood-based fuel out of the area and differences in extracting techniques.

The purpose is to improve the basis for local investment-decisions concerning energy in different types of municipalities.
The project will be a case study carried out through an ex-post investigation of already existing markets and plants in

- an pronounced rurl municipality with small opportunities for fuel "export".
- a mediumsized industrial municipality with fair large own demand for fuel and with "export" opportunities.
- a large industrialized municipality with a large demand for energy and with a size and location which give access to all possible alternatives for energy supply.
  A pilot project has already been carried out (3).

LITERATURE LITED

Perspectives om energyplanning in communes-an anthology. 1988. The State Board of Energy. Stockholm. (Only in Swedish).

Andersson, R , 1988: Basis for energy-prognostication. Energy and macro-economics for communes. The State Board of Energy. Stockholm. (Only in Swedish).

Engsds, J. and Hakansson, B. and Lidestav, G., 1987: The establishment of a municipal wood-based eating system from a regional macro-economic perspective - A case-study from a municipality in a forest dist*act in Central Sweden. The Swedish University of Agricultural Sciences. Department of Operational Efficiency. Garpenberg. Uppsatser och Resultat no 88. (Summary in English).

Working regions in cooperation. 1989. Report by the State Commission for Regional Policy. Stockholm. SOU 1989:55. (Only in Swedish).

Nilsson, I.and Wadeskog, A., 1983: The Crise, the Rural Areas and the Future- The Case of the County Jamtland. The county Council of Jamtland. SEE. (Only in Swedish).

The Report on Future Development. 1989. The State Department of Finance. Stockholm. LU90. Supplement 12. (Only in Swedish).

More independent Communes and the Policy of Labour Market. A macro-economic Study based on an actual Test. 1989. State Department of Labour. Stockholm. Ds 1989/21. (Only in Swedish).

FORESTRY AND RURAL DEVELOPMENT IN INDUSTRIALIZED COUNTRIES RESEARCH NEEDS FROM A PRACTIONERS POINT OF VIEW

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The Field Extension Agent is required to have excellent knowledge and skills in the subject areas which he is covering. However, he also needs good communication skills and a wide awareness of social, economic and regulatory environment in the communities where he is working. Suitable information in the later areas is not always readily available.

This paper identifies and structures subject areas where applied research can improve the efficiency of the Extension Agent. The presentation has been arbitrarily divided in seven subsections;

1. Organization, administration and regulatory aspects
2. Communication, education
3. Improved utilization, product development, marketing
4. Sociology
5. Biology
6. Economy
7. Appropriate technology

The conclusions are, that most extension activities require multi descipline research based on a well developed communication system between users, extension agents and researchers.

Without or with limited access to this well developed diversified research community, the efficiency of the extension agent decreases.

METHODS OF EVALUATING PROGRAMS TO STIMULATE RURAL DEVELOPMENT BY MEANS OF INTENSIFIED FORESTRY

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INTRODUCTION

Many programs to stimulate rural development by means of intensified forestry started in the late 1970's and early 80's. The negative state of the market, large groups of young people entering the labour-market without any jobs and a strong movement for rural development were the factors behind this trend. In a study we found 64 different programs that had been carried out in Sweden during the 80's. Different actors were found behind the progrwns.

To evaluate these programs a study with the title "Methods of evaluating programs to stimulate rural development by means of intensified forestry" (1), has been carried out by the author.

REVIEW OF PROGRAMS AND EVALUATION METHODS

In the literature you can find different methods of evaluating programs. Beside the pure cost-revenue methods (which are not usable in this case) I have studied political-economic methods, such as cost-benefit analysis, and evaluation research methods. In the latter category you find rationalistic, system oriented and action oriented methods.

Some of these information methods - e.g. cost-benefit analysis and rationalistic methods - need different kinds of causal - and hard data.

The action programs to intensify forestry, carried out in Sweden in the 80's, can be divided into three different main groups.

A. System-changing programs of a broad character.
B. Local development programs of a rather broad character.
C. Forestry sector programs of a narrow type.

We found totally 64 programs, of which 10 were of the A-type, 20 of the B-type and 34 of the C-type. In my study (1) I found 11 different evaluations made of 8 of those development programs. They have been carried out with different methods and the programs were of quite different character. Three of them had been evaluated by the author using a mixture of the three evaluation research methods listed above. These studies were carried out quite well but there was something important missing. It was easy to get the "hard-data" results (such as cash-flow in the program, jobs created by the program) but more difficult to catch the "soft-data" results (such as social effects, results of the program falling out in the future). Such effects are often especially significant in p*rograms of type A.

In my search for evaluation methods I found a political economic method called positional analysis. This is generally a planning method but I found that it might also be used in an expost situation.

POSITIONAL ANALYSIS FOR EX-POST STUDIES

The method called positional analysis was created by Peter Soderbaum at the Economic Institution of the University of Uppsala in 1973 (2). Soderbaum is an institutional economist and the method builds on some main conceptions. One of them is non-aggregation. If you compare positional analysis with some neoclassical method (for example cost-benefit analysis) you don't try to aggregate every result of the study to, for example, money. You attempt to separate each result in the entire study and even show them separated in the conclusions.

Another conception is a holistic view, which means that the method is open-ended and going across different sectors. A third is the thinking in positional terms. You use terms of state instead of terms of flow.

My adapted positional analysis checklist for ex-post use is listed below.

1. Problem pictures
2. System description
3. Positional determining
4. Effect dimensions
5. Activity/goal analysis
6. Summary and conditional conclusions

In order to test my adapted method I made a study of the action program of Bracke municipality in the north of Sweden.

The main result of this particular study is that the method of positional analysis also works for ex-post studies on the micro-level. It reveals all aspects of a program because it takes better care of soft effects than the other methods I have used.

LITERATURE CITED

Hillring, B. Methods of evaluating programmes to stimulate rural development by means of intensified forestry. Swedish University of Agricultural Sciences, Department of Operational Efficiency. Garpenberg. Sweden. To be published.

Soderbaum, P., 1973: Positionsanalys vid beslutsfattande och planering-ekonomisk analys pa tvarvetenskaplig grund. Scandinavian university books. Uppsala, Sweden. (In Swedish with English summary).

MANAGEMENT OF MUNICIPAL FOREST

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FDC: 922.2: 624: (485)

INTRODUCTION

In Sweden there are 284 primary municipalities. Many of these (82%) own forest land. A nationwide quetionnaire investigation (1) has shown that the collective area amounts to 341,000 ha. Furthermore, it can be stated that, to a large extent, planning and management of this land is done by extemal forestry organizations or companies.

Furthermore, many municipalities lack a pronounced goalsetting for management of their forest holdings. There is, therefore, reason to presume that the forestry planning process in general is characterized by a weak or non-existent degree of local political steering and control.

There is not found either, any tradition or demand that planning shall include consultation with the community's inhabitants, or procedures for display or remittance. These are common with other municipal operational planning.

The usual is that one instead uses a traditional forestry plan with a formulated goalsetting taken from the national level: "high and valuable timber yield". In such a plan, to be sure, consideration shall be taken to nature conservation and other interests. But, unmistakably it has the character of a sector plan. Also, the plan does not contain other consequence descriptions than those which touch on timber production.

In my opinion it has therefore been urgent to develop a planning technique which better corresponds to those demands one can place on a forestry operation in a municipal administration.

A planning technique, adapted to municipal forest ownership should thus:

- take into consideration the municipality's large multi-sector-covering role,
- pay attention to local conditions,
- provide allround illumination of the consequences of altemative management and operational for*ms,
- reveal conflicts.

All this is with the thought of generating a decision basis which favors the democratic decision process, which concludes with the plan's ratification.

The work which is presented below has been limited to apply to development of the decision base and does not include the forms of the decision itself.

PIKS - A PLANNING TECHNIQUE FOR MUNICIPALITY-OWNED FORESTS (2)

With certain modifications, PIKS is a combination of two existing planning techniques. The one, position analysis, is a generally usable technique which has had to constitute the greater framework coverage, while the other, Plan-20, is a pure forestry microcomputer-based planning routine.

Position analysis (3) has its roots in institutional economy, which emphasizes a holistic view, the importance of rules of play and power relationships plus the necessity of ideological and methodical openess in relation to other sciences. It means that one works with an expanded and multi-dimensional economic concept instead of attempting to reduce complex occurrences to one and only one monitory dimension.

On the other hand, Plan-20 (4) builds on traditional (neo-classical) forest economics theory. With this help one can attain a market-adapted management program for production forestry. It is primarily the private and business economics aspects which are emphasised, while the political and national economic considerations must constitute the frame within which the enterprise can act.

In order to test the planning technique, a municipality in central Sweden having approximately 20,000 inhabitants and 4,500 ha forest land was elected as an application object. A problem description comprised the general conditions of the community and how the municipal forest was treated in existing plans, planning foundation and agreements. From this problem description, four different treatment programs were generated for the management of the municipal forests during a 10-year period.

Starting with these altemative treatment programs, a system structuring was then done. That is, identify those systems which can possibly be influenced in different ways, depending on the altemative chosen. Those systems identified in this application study are:

- land as a physical system,
- system for forestry,
- system for timber supply,
- moriitary system,
- energy supply system,
- labor market system,
- social system,
- institutional system

Afterwards the treatment programs were compared with regard to the expected effects. An effect analysis was used. Attention was directed to the disparity between the alternatives in different relevant dimensions. Where it was possible and considered meaningful, the effects for the respective alternatives were quantified. In other cases, those comparisons of a more qualitative nature were the most interesting. The degree of uncertainty in computation were also given.

The next step was to show, with an interest analysis, which interest is favored, or misfavored, by one or the other altemative. interest is defined as an activity coupled to an assumption about goal direction.

For each interest an order of preference was then given. That is to say, which of one or several alternatives best matches a certain interest. By placing together the total collection of interests and preference orders in matrix form, an overview is obtained of conflicts and consensus. Conversely, no assumption is made of how lone individuals are influenced by different alternatives, since individuals often participate in several different activities and thus "represent" different interests.

Finally, there was formulated a number of conditional conclusions out of those effect and interest analyses done earlier. In this case none of the treatment programs clearly point to being best or worst. To evaluate and weigh together those different effects and interests may therefore be a position question each and every one has to take regarding municipal forests management and operation.

As administrator/planner, one can indeed attempt to articulate some different evaluation approaches. You can test them to the extent that they are compatible with the various treatment programs. However, those conclusions drawn can only be regarded as conditional.

LITERATURE CITED

Lidestav, G., 1989: Community-owned forest - The scale and management of municipally owned forest. The Swedish University of Agricultural Sciences, Department of Operational Efficiency. Report no 183. Garpenberg, Sweden. (In Swedish with an English summary).

Lidestav, G.: PIKS - Planeringsinstrument for kommunagd skog. (Eng: PIKS Planning instrument for municipally owned forest). The Swedish University of Agricultural Sciences, Department of Operational Efficiency. Garpenberg, Sweden. (To be published).

Soderbaum, P., 1973: Positionsanalys vid beslutsfattande och planering. Ekonomisk analys pa tvarvetenskaplig grund. (Eng: Positional analysis for decision making and planning. Economic analysis on an interdisciplinary foundation). Scandinavian university books. Uppsala, Sweden. (In Swedish with English summary).

Ekvall, H., 1986: PLAN-20. Ett skogligt varderings- och planeringssystem. (Eng: A forest planning system). The Swedish University of Agricultural Sciences. Department of Forest Economics. Umea, Sweden. (Only in Swedish).

ANALYSIS OF PEOPLES'S EXPECTATIONS FOR FOREST FUNCTIONS

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FDC: 901: (52)

Inquiries about people's expectations for forest functions were made in miyazaki-shi, the local centre of political administration, business and education; Nango, a base for deep-sea fishing; Morotsuka, a typical small village living on forestry to obtain information about them. The recipients of the questionnaires, who were systematically drawn from the election rolls in each region and from the lst-year students in the Faculty of Agriculture in 1989, were requested to answer the question:

"The total area of Miyazaki Prefecture amounts to 773,400 ha, ca. 3/4 of which is covered with forests. The following are the general forest functions. How do you rank them according to their importance, when you consider them for the prefecture as a whole?

Forest functions	Rankings
Wood production	( )
Defense against landslides	( )
Water protection	( )
Recreational uses	( )
Landscape	( )
Habitat for wildlife	( ) "

In the case of ranking of individual forest functions, with the exception of the lst-year students, there was a common pattern of concentration among these 3 regions, from the most often chosen to the least, of wood production, water protection, defense against landslides, habitat for wildlife, landscape and recreational uses. The ranking pattern by those in their twenties in Morotsuka resembled that of the region as a whole, but that by the same age-class in Miyazaki-shi showed a different one from that of the city as a whole, namely, defense against landslide, water protection, habitat for wildlife, landscape, recreational uses and wood production.

Then each of the 3 most often chosen functions was connected with one of the other 2 most often chosen. This produced 6 possible permutations, which were then analyzed by primary application of the set theory.

If we denote

N :the size of a sample,
A and B :2 different kinds of forest functions,
n(Al) :the number who ranked the function A as lst. The figure affixed shows the rank
n(B2) :the number who ranked the function B as 2nd,
n(Al n B2) : "meet" or "intersection" of 2 sets, Al, and B2
and
n(AI U B2) : "join" or " sum of 2 sets, Al and B2",
then
n(Al U B2) = n(Al) + n(B2)-n(Al n B2)

Accordingly, there can be the percentages:

r21 (%) :n(A1 n B2)/n(A1 U B2) * 100
r22 (%) :n(A1 n B2)/N*100, and
r23 (%) :n(A1 U B2)/N*100

The results of the analysis entirely agreed with the common image Of each region held by the people of those regions. There were different patterns of ranking among the younger people compared with those of the older within the same regions. A majority of the older ranked permutations of 2 out of the 3 functions (wood production, defense against landslides and water protection) highest. Subjects in their twenties who ranked these functions in the highest 2 ranks were, however, only a minority in each region, with only one exception of Morotsuka.

A further application of the set theory to the 3 highest ranks was also made.

Denoting, additionally,

A,B and C :3 different kinds of forest functions most likely to occur,
n(C3) :the number who ranked the function C as 3rd. The figure affixed is the rank,
n(B2 n C3) :"meet or "intersection" of 2 sets B2 and C3: the number who ranked the function B as 2nd and the function C as 3rd,
n(A1 n C3) :"meet or "intersection" of 2 sets A1 and C3:the number who ranked the function A as 1st and the function C as 3rd,
n(A1 n B2 n C3):"meet or "intersection" of 3 sets A1, B2 and C3,: the number who ranked the function A as 1st, the function B as 2nd, and the function C as 3rd, simultaneously, and
n(A1 U B2 U C3):"join" or "sum of 3 sets A1, B2 and C3" : the number who ranked either the function A as 1st, the function B as 2nd or the function C as 3rd,

then
n(A1 U B2 U C3)=n(A1)+n(B2)+n(C3)- { n(A1 n B2) + n(B2 nC3)+n(A1 n C3)}+n(A1 n B2 n C3)
Similarly calculated are

r31 (%) :n(A1 n B2 n C3)/n (A1 U B2 U C3)*100,
r32 (%) :n(A1 n B2 n C3)/N*100, and
r33 (%) :n(A1 U B2 U C3)/N*100

r21 (%) and r31 (%) could be regarded as measures for the closeness of the relationship between 2 or among 3 forest functions, respectively.

From the results we obtained, it can be concluded that the analysis of people's expectations for forest functions becomes more quantitative and objective by an application of the set theory. For this purpose it is recommended that above-mentioned quantities be used:

"meet" / "join" *100, "meet" /N*100 and "join" /N*100, namely;
r21, r22 and r23, when 2 fuctions are adopted for the 2 highest

THE ROLE SMALL SCALE FORESTRY IN STABLIZING RURAL COMMUNITIES IN BRITISH COLUMBIA, CANADA

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The population of British Columbia is increasing at about 1.5% annually, mainly from immigration. The majority of immigrants settle in urban areas, few electing the rural environment. In some instances, the population of rural communities in the Province are declining, although depending on prices for raw materials from primary resource industries such as oil, timber, and coal, populations do fluctuate dramatically from one economic period to the next.

Due to land ownership patterns in British Columbia, where the Crown owns 94% of all productive forest land, there is little opportunity for the citizens of the Province to actively participate in managing land, and less than 1% of the population owns a woodlot of more than 20 hectares.

When examining rural populations both in Canada and other parts of the world, and comparing the productivity ans stability of the rural economy, it is found as a general model, that where a high proportion of forest land is privately owned land in small ownerships, and the rural populations are actively engaged in a combination of forestry and farming, the rural economy is deverse, strong and population levles stable.

There is considerable interest in woodlot management in British Columbia, and this interest is increasing. However, there are barriers, both politically and economically, to increasing involvement in the farm/forestry process. Whereas there has, in the past, been active encouragement for persons to acquire farm land, and invest effort in making the enterprise economically viable, there has been little opportunity or incentive to acquire forest land, and invest time and energy in growing trees. This in spite of the fact that more than half of all the eocnomic activity in British Columbia is derived from the sale of forest products.

The farming community tend to view their woodlots as a minor investment, focusing more on the use of the forest for grazing and minor produce such as firewood and fencing material. However, where land has been managed for an intimate combination of woodlot supplemented with a small

THE STRUCTURE OF FORESTRY EMPLOYMENT IN MOUNTAIN VILLAGES IN A PERIOD OF SLOW ECONOMIC GROWTH AND REVITALIZATION OF THE VILLAGE

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INTRODUCTION

In this paper, after first examining the forestry problems in the most depressed period statistically and in practice from the aspect of the employment trends, the author examined the town of Shimokawa, Hokkaido, through an on-the-spot survey concerning the revitalization of the town centered on forestry as one of the most important sources of employment for the mountain village; and from this he considers the problems on the future directions in "Village Revitalization".

THE EMPLOYMENT STRUCTURE IN THE MOUNTAIN VILLAGE IN THE PERIOD OF LOW LEVEL ECONOMIC GROWTH

What can be pointed out from the analysis, is the lowering in the level of the forestry labor force both quantitatively and qualitatively, and the specialization of forestry labor. Concerning the meaning of these figures, in the former are shown the management rationalization and mechanization aiming at a rise in productivity within the retrenchment in the forestry, and in the latter are seen a movement of capital to secure a basic labor force within the industry in competition with capital of other industries, and the movement of the laborer toward stable employment.

As can be understood from the analysis of the town, it can be pointed out in Shimokawa as well that, as indicated in the analysis of the national statistics, there is rationalization of forestry management and a qualitative decrease in the forestry labor force.

LOCAL REVITALIZATION AND FORESTRY: A CASE STUDY OF SHIMOKAWA

In connection with movements to revitalize the towns, the relation of the local governing bodies to the people of these localities is divided into three types. The first is a type in which the townspeople are the main force; the second is a combination of the people and the local government; the third is that in which the local government prevails. However, while this might be true on the surface, at the point of implementation there is a need to examine the financial backing of any operation, and the upshot of this is that in any case the result will be the combination of local government and the people. It is very much so in the case of Shimokawa which will be considered below.

1. Village revitalization in Shimokawa

The effort to stop the outflow of population resulted in a drive to "change your point of view", with which the "Hometown Movement" started in 1981. The author wants to tell you some of the practical results of this movement.

i. Hometown Membership System
ii. Mother a Calf Membership System
iii. Hometown in the Year 2,000, Forest Membership System

2. Charcoal manufacturing in Shimokawa as a means of revitalization

Tied in with these movements of the townspeople, there is the production of larch-log charcoal and development of related products carried on mainly through the forestry cooperative.

CONCLUSION

With the reduction in the town's basic industry, forestry operations and the closing of the Shimokawa Mine in the town, the development of charcoal and related products manufacture was carried out mainly by the forestry cooperative in seeking a way to promote forestry, the chief industry. This charcoal manufacture, from the viewpoint of effective use of material from thinning in larch forests and the creation of employment opportunities in a local industry, is of great importance. The whole chain of activities from promotion of thinning through the purchase of larchwood at a higher price than that for pulpwood, and resisting the outflow of population by manufacturing charcoal and making full use of its possibilities, and even furthering soil resuscitation through the use of charcoal in soil improvement is a fine achievement.

At the same time, it was not attained only through the efforts of those directly involved in the projects, centered on the forestry cooperative, the will of the townspeople to resist the outflow of population crystalized in the "Hometown Movement" supports it. And also, the municipal aid granted by the directors of the town cannot be overlooked.

It has also to be said that the various products connected with charcoal as well as smoked alcove posts, smoked column materials, wood venigar, and activated charcoal could not have been brought to realization without the financial aid of the township government as well as the subsidies of the national government under the "Thinning Promotion Measures Project", "New Forestry Structure Improvement Project", etc. The author thinks, therefore, that the real evaluation of the cooperative's operation can only be made at the point at which these subsidies are no longer granted and the projects have to stand on their own merits. The securing of a market for the products especially is an urgent need.

After saying this, however, it must be realized that the organization of forestry through the forestry cooperative is only one pole. Together with the organization of agriculture in the manner, for example, of the town Shihoro with its production and processing of potatoes, there is a need to organize the ties among the local people. In Shimokawa, future dreams include the drying of lumber, big greenhouse cultivation and a warm water swimming pool to attract tourists all using heat recovered from the production of charcoal.

In conclusion, to progress the revitalization there is a need to provide a situation in which promotion and discussion among the townspeople and the representatives of the various organizations and industries can take place.

SINGLE-INDUSTRY FORESTRY COMMUNITIES: A NATIONAL AND REGIONAL (NORTHERN ONTARIO) PROFILE

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Canada is a nation richly endowed with forests. These forests are part of the landscape of every province, and cover 44% of the country's total land area. Since the early days of settlement and the beginning of the logging industry, the nation's economic, political, and social development has been inextricably linked to the forests. The forest products sector has continued to be a significant contributor to Canada's national and regional economic well-being since those early years. Single-industry communities play an important part in Canada's economic structure. Approximately 75% of Canada's 26 million people are concentrated in the larger metropolitan areas; the remainder are found in scattered rural farming areas as well as in remote, resource-based communities.

The paper is divided into three parts. Firstly, the results of a recent study conducted by Forestry Canada of Canadian communities dependent on the forest sector are highlighted; secondly, a resource-based region within the province of Ontario very much dependent on the forest sector is described; and, thirdly, a typical single-industry forestry community in this same region is discussed in terms of its current and future infrastructure.

The Forestry Canada report identified forest sector-dependent communities, as they existed in 1981, using data from Canada's 1981 national census. It was found that approximately 900 communities across the country relied totally or partially on forest sector activity. Of these communities, 348 were identified as being almost totally dependent on forest sector activities. Of these, 105 had a population of over 1,000 (avg 1,500). A number of socio-economic variables-- community distribution, age distribution, education, income, employment levels and housing were examined. For the 105 communities, analysis revealed that the level of formal education was low in these communities when compared to other communities in Canada. Forest sector workers' income was high relative to the average Canadian worker, and significantly greater than the average income of all other workers in these communities. Income levels were highest amongst workers in the pulp and paper industry and lowest in the secondary wood-using industries. At the time the census was taken, the unemployment rate in the 105 communities was marginally higher than that in rural communities as a whole, and, in turn, was marginally higher than the average unemployment rate for Canada. Generally speaking, rural unemployment rates are higher than those in the larger urban areas.

The paper describes northern Ontario, a region of the province of Ontario comprising 90% (892,000 sq. km.) of the land base and containing 9% (793,000) of the population. This region depends a great deal on the extraction of primary resources and on primary manufacturing for its economic stability and well-being. Seventy percent of manufacturing jobs are dependent on the resource-related sectors. Just over one-half of the population is located in five of its largest urban communities. In contrast to this is the predominance of small rural communities. There are 162 municipalities with populations of less than 3,000. Approximately 50 communities rely on a single resource industry and 35 of these have a population of less than 2,500. Over 30 communities depend totally or partially on the forest industry for their economic survival. The forest sector draws its wood supply from an extensive forest estate. Total employment in the sector throughout the region is approximately 37,000. The pulp and paper industry is, by far, the largest and most important in terms of both employment and value of production. Of the 20 mills that produce pulp and/or paper in the province, 17 are located in the region. Of the eight newsprint mills, seven are located here. Of the 700+ licensed softwood and hardwood mills, over 325 are located in northern Ontario. Most the the province's panelboard mills are also located in the region.

The last part of the paper describes a typical single-industry forestry community in northern Ontario. Espanola, a small town with a population of approximately 5,500, is totally dependent on a single pulp and paper mill that employs about 31% of the local labour force (2,600). Several socio-economic variables--labour force, education, and age distribution are discussed and compared with the findings of the Forestry Canada national study. The array of problems the town faces to diversify and expand its industrial and service sector in order to to maintain and strengthen its economy is no different than that faced by hundreds of resource dependent rural communities across the country. Espanola is facing the challenge, but diversification will be expensive, time consuming, and a long-term undertaking. Despite government programs in place to assist in the process, the onus is on municipal leaders, the business community, community residents and the major employer, working to-gether, to make it happen.

ADMINISTRATIVE POLICY MAKING: THE EXAMPLE OF REGIONAL FOREST PLANNING

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SUMMARY

FDC: 903: 681: 945.14

The theory of APM renders it possible to systematically recognize the causes of erroneous developments in forestry and to support the attempts of practical forestry to solve these problems with strategies based on this understanding. Taking regional forest planning as an example, the following causes for the failure to realize target-oriented planning are pointed out: an informal disinclination of the forest authority to being bound by plans, resistance of forest owners and other public entities, degeneration of planning efforts into symbolic planning devoid of substance but of great appeal to the public. The strategies of improvement attacking the problems at their roots derived from this analysis include the use of external planning agents, the information of forest owners on the optimum use of space, the penetration of forest planning into other public domains by providing strictly factual information, the renouncement of strong public appeal so as to reduce the symbolic impact of planning and the creation of a competitive situation for all types of all natural-area-related planning.

Keywords: symbolic politics, forest regional information system, forest authority.

ANALYSIS OF ADMINISTRATIVE POLICY MAKING (APM) AS A BASIC FEATURE OF SUCCESSFUL FOREST MANAGEMENT

Foresters working in a specific sector for decades usually also acquire knowledge about undesirable trends. They critically make note of ecological damage to the forest as well as of shortcomings of forest use of an economic of technical nature. The committed forester neither fails to notice a destablization of forests caused by emission impacts or wrong exploitation methods, not does he fail to see a lack of economic efficiency in the sale of timber. Having clearly identified these shortcomings, many foresters step up their practical efforts to achieve improvements. Many foresters frequently complain about opposition of a political nature. However, they counteract this opposition by increasing their battle on a practical level and refuse to be kept up from their work by a "theoretical" analysis of APM. This misinterpretation of sociological analysis underrates the degree to which such an analysis may contribute to solving problems arising in forest management. Just as the forester equipped with know-how in silviculture based on ecological research is able to take more effective measures, the forester who has acquired a greater insight into the process of forest policy making by means of the analysis of APM will be able to take targeted action to improve the political framework conditions for solving forestry problems. The same practical efforts, which remain still, would thus promise greater success in forestry issues.

The most important domain in which the analysis of APM provides valuable information is in the recognition of political causes of undesirable trends. While the practical forester perceives the risks for the forest and immediately tries to fight them with traditional measures, the analysis of APM precisely perceives the risks and moreover defines their socio-political causes. Only then does it try to seek counter-strategies, which are all the more effective as they attack the erroneous developments at their roots. In many instances neither new laws nor even a much bespoken but hard to attain "reorientation towards a society which thoroughly reacts to the needs of the forest" are necessary, the careful use of existing political instruments alone would suffice to decisively improve the situation of forests and of forestry.

This paper uses regional forest planning as an example to illustrate to what an extend and in what fashion the analysis of APM may be instrumental in pointing out political strategies at the basis of such erroneous developments. The exact formulation of the problem is followed by a short review of the fundamental principles of analysis of APM. The main part of the report centers on the political practice of regional forest planning. Finally the analysis leads up to improvement strategies for this not exceedingly successful field of forestry. The chief purpose of this example of regional forest planning is to highlight the efficiency and practical import of analysis of APM.

FORMULATION OF THE PROBLEM

Rational and targeted planning of forest-related regional development is chosen as a guideline for regional forest planning in this paper. Such planning aims at the ideals of a comprehensive regional analysis, a clear determination of the targets of forest-related use of space, the selection of the most appropriate instruments to attain these goals and the practical implementation of planning strategies (Bechmann 1981). Having established this planning ideal, its possible realization in practical forestry shall be examined.

The analysis of APM starts out by exactly describing the process of planning in forest policy, which ranges from the efforts to create a statutory basis for regional forest planning to drawing up plans by the forest authority to influencing the forest-related use of space.

In addition to a comprehensive and realistic description, the analysis tries to find explanations for what happens in planning. In doing this it is based on the theory of APM, which claims the ability to explain all acts of the authorities, i.e., also their planning efforts, based on empirical proves.

Finally, the determination of the reasons for certain deviations from the ideal concept made in practical planning renders it possible to formulate strategies which in practical forest planning may help to approximate the ideal.

Regional forest planning as examined in this context is based on the entire forest-related regional development of an area. Being a discipline of regional planning it comprises all the different types of forest enterprises and forest owners in the planning area. Therefore it differs from the more traditional type of forest planning related to individual enterprises and owners, in particular from the type of planning merely related to state-owned forests. The empirical basis of the analysis is derived from the planning experiences made during the past 25 years in Austria and in Germany (Krott 1989<2>).

THEORETICAL BASIS

A short delineation of the theory of APM will highlight the theoretical basis on which the results obtained by means of regional forest planning are founded. The theory of APM immediately relates the theory of policy process to organization theories about the forest authority. All action taken by the forest authority has a more or less pronounced impact on the political process. In this process some of the many issues are signaled out and programs for their solution are formulated mostly in the form of laws. Provided these programs are then implemented, they may contribute to solve problems in forestry.

The theory of APM pays the same degree of attention to the process as to the various entities involved. The forest authority, other authorities, forest enterprises, their interest groups, politicians, etc. keep acting on the political process to obtain results which are as favorable as possible for the interests they represent. The theory of APM is able to take the exact interests of the respective entities into account by means of the "action plan." The theory is based on the assumption that each entity publicly professes some of its intentions and keeps some of them secret. It defines formal and informal goals and levels of action.

In implementing these goals the entities resort to information and power. The features of the different means of information and power as well as their impacts, as described in detail by the theory of APM (Krott 1990), will not be listed in this context; they will be mentioned only in so far as they help explain the process of regional forest planning.

RESULTS

A representation of the results of the analysis provides an initial survey of regional forest planning in practice and then explains its course. For the sake of clarity and empirical precision the survey is restricted to Austria as a model. However, scientifically established material from West Germany is also quoted in explaining the planning process.

Planning in Practice

When they took up regional forest planning about 25 years ago, foresters and forestry embarked on a then completely new field. Traditional forest planning always dealt simply with forest use on the part of individual enterprises and not with the aggregate forests in a specific area with the manifold demands made on them. The regional planning approach to forestry, which goes beyond forest use on the part of individual enterprises, required new goals and planning procedures.

Experts of forest interest groups and the forest authority made themselves familiar with the unknown domain.

They succeeded in making these new concepts part of the efforts for a new forest law. After about a decade of ups and downs in policy formulation the target was attained, the forest law for the first time made provisions for regional forest planning in a separate section. It defined general planning targets and demanded a statewide regional plan for the entire country. This task was entrusted solely to the forest authority.

Even before being formally assigned the task, the forest authority endeavored to throw more light on the objectives of planning. It set up an internal working group, sought the support of people engaged in forest science and drew up test plans. Starting from the concept of means and ends planning the authority elaborated a number of planning processes and tried to lay them down in law. In the course of that decade, which was dedicated to efforts to have regional forest planning standardized by laws and its objectives exactly defined in the form of regulations and standards, the objective of planning underwent a systematic change. The planning approach moved further and further away from the principles of means and ends planning. While the determination of targets and future approaches withdraw steadily into the background and finally almost disappeared behind merely general statements, the descriptive representation in the form of a statewide plan evolved as the main feature of the planning process.

In practical policy implementation the forest authority on the one hand held on to the concept of representing forest-related regional development in plans. It spent a lot of efforts on elaborating highly illustrative maps of forest functions, in which positive functions, such as producing timber, protecting settlements and traffic routes, safeguarding the water supply or providing for recreational areas are assigned to all forests in Austria. The value of these functions is described in a uniform classification, whose validity is underscored by invoking provisions in the forest law. In this way the forest authority set up statewide plans immediately reflecting the manifold positive impacts of the forest on the respective region.

To fulfill the assignment of drawing up planning concepts which state relevant targets for the future, which is regulated by law, the forest authority in practice resorted to an auxiliary method. Since planning failed to establish meaningful targets exactly defined in terms of space, future measures had to be defined without being able to resort to such targets. However, the planning forest authority could turn to another guideline. Its day-to-day administrative work provided the forest authority with rich experience in forestry problems so that it could resort to time-tested standard solutions. In the regional forest plan these measures were listed as they exist in the respective region, so that a set of "contingency plans" deduced from day-to-day administrative work completes these plans.

In summary, the political process of regional forest planning involves the statutory standardization of the forest authority's new planning assignment and the loss of planning objectives during the practical planning process and results in the elaboration of maps of forest functions of great symbolic power. These are completed by a list of future measures deduced from the experiences made in practical administration work (Fig. 1). This result is far removed from the idea of a target-oriented shaping of forest-related regional development. At this point the question arises why these deviations occurred in practical planning.

Explanation of the Course of Planning

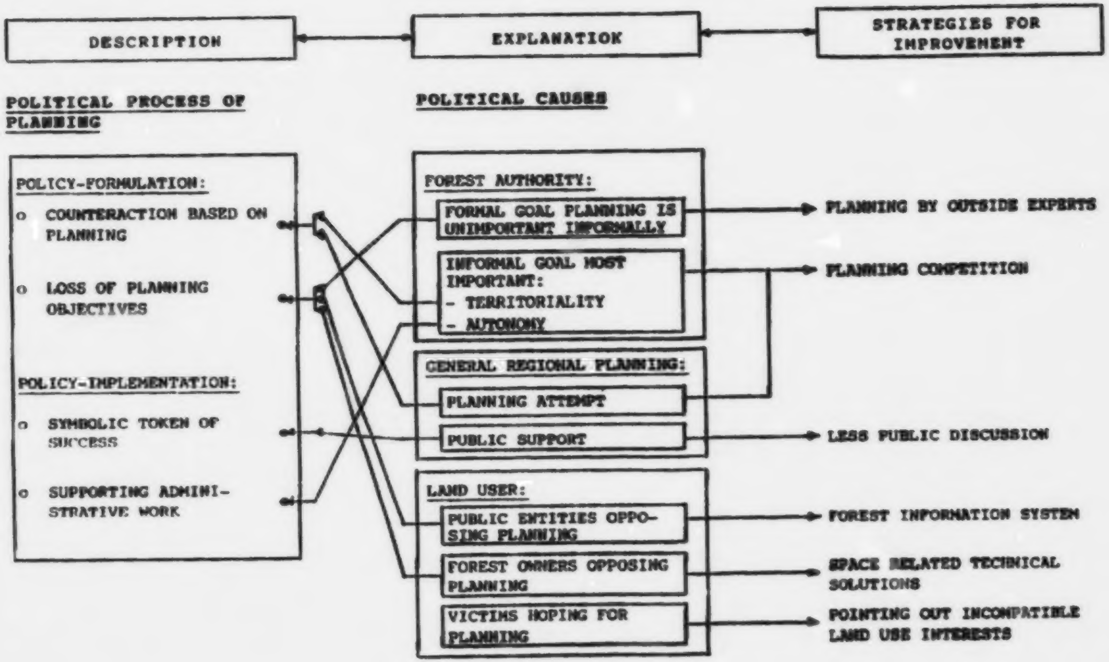
Counteraction Based on Planning

Regional forest planning creates a new domain in forestry. Since such innovations can only rarely be enforced in policy formulation, it is a special challenge for the theory of APM to give an explanation of such innovations. The reasons for the introduction of regional forest planning given in the relevant section of the new law and in numerous official statements are not satisfactory once they are examined more closely. Regional forest planning is said to be necessary to safeguard the manifold positive effects of forests on general living conditions and the economic situation. As always in politics, only "material grounds" are cited to justify the new instrument, just as if there were no other reason for political action. The target of protecting forests does not suffice as a reason, because it is not able to explain why regional forest planning was introduced in the 1970s and not earlier, when foresters had already started to issue warnings about the dangers to forests. This kind of reasoning also leaves the question unanswered why there is so little interest in regional forest planning even today although the dangers for forests have increased. Most important, however, the mere statement that problems must be solved by means of regional planning by no means suffices to explain why this task is to be fulfilled by the forest authority rather than by general regional planning.

Therefore, if the problem is to be explained adequately at all, important additions have to be made to the all too simple but not incorrect argument that the new instrument was developed because region-related problems of forest protection and development required a solution. At the end of the 1960s foresters became aware not only of increased demands on forests made by new groups, they also realized that the targets and instruments of general regional planning were starting to embrace forests. If general regional planning were to control forests and their use, the forest authority's scope of activity would be severely restricted. This informal target of territoriality of the authority, i.e., the protection of its scope of activity (Downs 1967), prompted the forest authority to seek a counter-strategy. The danger was judged to be so serious on an informal level that such an innovative step as taking over planning by creating a new instrument did not only seem possible, but soon appeared desirable in practice.

A further informal feature of forest policy explains why the forest authority succeeded in enforcing this objective in policy formulation: The interest groups of forest owners disapprove of any attempt at regulation restricting the freedom of forest enterprises made by outsiders. Consequently they take a negative stance on any kind of planning approach.

FIG. 1: **FOREST REGIONAL PLANNING: PRACTICE AND IMPROVEMENTS**


DESCRIPTION
EXPLANATION
STRATEGIES FOR IMPROVEMENT
POLITICAL PROCESS OF PLANNING
POLICY-FORMULATION:
o COUNTERACTION BASED ON PLANNING
o LOSS OF PLANNING OBJECTIVES
POLICY-IMPLEMENTATION:
o SYMBOLIC TOKEN OF SUCCESS
o SUPPORTING ADMINI-STRATIVE WORK
POLITICAL CAUSES
FOREST AUTHORITY:
FORMAL GOAL PLANNING IS UNIMPORTANT INFORMALLY
INFORMAL GOAL MOST IMPORTANT:
- TERRITORIALITY
- AUTONOMY
GENERAL REGIONAL PLANNING:
PLANNING ATTEMPT
PUBLIC SUPPORT
LAND USER:
PUBLIC ENTITIES OPPO-SING PLANNING
FOREST OWNERS OPPOSING PLANNING
VICTIMS HOPING FOR PLANNING
PLANNING BY OUTSIDE EXPERTS
PLANNING COMPETITION
LESS PUBLIC DISCUSSION
FOREST INFORMATION SYSTEM
SPACE RELATED TECHNICAL SOLUTIONS
POINTING OUT INCOMPATIBLE LAND USE INTERESTS

As an answer to the imminent attempts at planning on the part of general regional planning with the hope of being able to play off general regional planning against the forest authority in practice and thus generally to weaken the regulative power of the government, or they could support the forest authority's efforts to create an instrument of planning of its own and thus at least keep the new planning authority from the forests. The forest interest groups clearly decided in favor of the second strategy, which fits in well with the common "corporatist" forest policy of the authority and the interest groups. The first, pluralistic option of changing alliances was not seriously taken into consideration (Peters 1984, p. 146). Thus the readiness to take counteraction in the form of forest planning, which is explained by the forest authority's formal objective of protecting its territoriality, was supported by the corporatist alliance with the forest interest groups in such a way as to result in the innovative step of embodying regional forest planning in law.

Loss of Planning Objectives

Although the law formally assigns the task of planning to the forest authority and provides for the comprehensive means and ends planning procedure, the legal formulations are kept in such general terms that they cannot prevent planning from being voided of its objectives, mostly on an informal level. Influential entities force the planning approach to be curtailed in policy formulation. The representatives of forest owners strictly oppose all approaches to deal with region-related issues regarding forest enterprises in regional forest planning. But also the concept of making the use of forests by nonforest entities, constructors of roads and power stations, e.g., subject to planning meets with most fervent opposition. The public institutions concerned are by no means willing to have their construction projects made dependent on regional forest planning. Threatened in its existence by protest both from within and outside the ranks of forestry, the planning program is restricted to nothing more than very general statements representing recommendations without binding force. Kohler (1982) describes this same type of weakness in German regional forest planning.

The forest authority is bothered little by the loss of planning substance on account of its informal goals. On the contrary, it perceives advantages in this weak point, because a binding means and ends planning in many ways complicates the work of the authority: The comprehensive analysis on the use of space makes apparent a great number of problems and, the more evident these problems become, the more the pressure on the forest authority increases to have them settled in spite of the efforts this requires and the conflicts it entails. Definite objectives also result in additional difficulties for the authority. Explicit targets regarding the use of space give rise to quick protest by those who believe they will be put at a disadvantage. Moreover, they make it possible to rate the achievement of the authority. Finally, the binding definition of goals and measures makes the action the forest authority is to take completely predictable for its opponents and deprives the authority of the use of the often successful strategy of flexible response. In practical administration, where, contrary to the ideal assumptions of constitutionality, any decision by an authority can be enforced only in a piecemeal fashion by first exerting a considerable degree of power, definite means and ends planning entails new problems for the forest authority, which it prefers to avoid on an informal level.

This situation in Austria only seemingly contrasts with the definite means and ends planning applied by the German forest authority in state forests, because of course forest management planning in state-owned forests does not imply the degree of political conflict settlement typical of the forest authority's dealings with forest owners and other forest users. In managing state-owned forests the planning forest authority disposes of relatively ample means of enforcing its power, a factor favoring means and ends planning. As soon as the influence of the forest authority becomes weaker, as in statewide regional forest planning, means and ends planning becomes a burden, which is readily avoided on an informal level.

Symbolic Token of Success

In spite of the loss of planning objectives, the forest authority has drawn up a set of plans in practical policy implementation. As already mentioned, the forest function map, on which it centers, has a great deal of symbolic power signaling successful solutions for forests as well as forest planning competence to the public. The question is why this symbolic effect works and who intended it.

As soon as the problems regard larger spaces or even an entire country, the individual citizen is unable to form an opinion based on direct experience about forest-related problems regarding the use of space. Nobody is able to judge with his own eyes whether the wooded area in a country is increasing or decreasing unless he takes recourse to other means, trusting statistic inventories for example. But it is not only impossible to form a direct opinion about conditions, it is just as impossible to keep track of the effects of long-term solutions. The desired improvements of the situation of forests generally take a very long time to evolve and the persons who initiated or demanded the respective measures have already died by that time. Moreover, a very large group of people benefits from the positive impacts of forests, namely all those people whose settlements, water resources or climatic conditions are protected by the woods. According to Edelman (1976) symbolic political solutions are most effective if the groups of people concerned are very large and the individual impacts are difficult to assess. This is explained by the fact that in such a case the large group can do nothing but rely on promising individual signs--i.e., symbols--to judge the success or failure of the respective political solution. At present the public is not in a position to form a well-founded, rational opinion on large-scale and long-term problems regarding the use of space permitting a critical view of the radiating power of symbolic solutions. For this reason symbolic solutions, such as highly illustrative maps of functions evoking people's trust, potentially are of great political impact.

Prompted by the wish to prove its planning competence for forests, also the forest authority related heavily on the symbolic power of illustrations of forest functions from the outset. Even though foresters in Austria as well as in Germany did become aware of the methodical weaknesses of an assessment of functions, they did not wait for specialized, well-founded evaluation procedures to be developed but, based on simple procedures began to draw up area-wide maps (Kohler 1984, p. 122; Arbeitsgruppe 1973). The more regional forest planning for the reasons stated above lost substance in terms of means and ends planning, the more the forest authority relied on the symbolic effect of the maps. What is more, in the 1970s "planning" as such represented so much of a symbol of progressive politics that any group which even announced a planning program or a plan already gained authority with the public (Klages 1971). Naturally, the forest authority would not have ignored the symbolic effect of the new instrument.

Planning Approaches Subordinated to Administrative Work of the Authority

Beside very general and therefore rather indefinite targets, the planning section of forest plans contains proposals for a number of future- and practice-related measures. This "contingency planning method" is by no means part of some theory of planning, but a result of the forest authority's informal concept of its function. On an informal level it also bases new regional forest planning on time-tested methods of day-to-day administrative work. Thus it does not aim at new regional goals, but rather views regional development in the light of instruments already provided for in forest laws, such as the forest preservation and the provisions relating to recreation and protective woods. The formal claim of planning to establish goals and to see to it that they are achieved in practical policy implementation becomes inverted. On an informal level practical administrative work determines the possible measures, on which, in turn, the definition of targets is based. To state and example, regional forest planning analyses the recreational function of forests only to the extent provided for in forest law. Also, regional forest planning completely ignores the role of forests as a habitat for game, since hunting is not within its range of competence. Thus the definition of targets and problems in forestry is completely subordinated to the day-to-day administrative routine.

The predominance of the authority's established working routine over target-oriented planning also extends to the authority's informal strategy of incrementalism (Richardson et al. 1979). Generally the forest authority does not deviate much from existing regulations in defining planning targets because it may expect that these regulations correspond best to the actual distribution of political forces. In the eyes of the forest authority any great deviation is a major risk to be avoided. It is this informal attitude that seriously prevents the planning authority from taking up the formal mandate of regional forest planning to define new targets and new ways of regulating forest-related regional development in line with the principles of means and ends planing. Instead, the forest authority gives preference to the "more modest" measures derived from day-to-day administrative routine.

STRATEGIES TO ACHIEVE TARGET-ORIENTED REGIONAL FOREST PLANNING

This analysis has pointed out the different causes within and outside of the forest authority impeding the achievement of ideal, target-oriented regional forest planning. This knowledge opens up an opportunity to impact on these causes by means of appropriate political strategies in order to approximate practice to the ideal of planning and thus to contribute to the solution of the problems of the forest-related use of space as well as to enhance regional forest planning in the long term:

1) Planning by outside experts instead of reinforcing the planning forest authority.

In the present situation it is not so much the reinforcement of the planning forest authority that could lead to better results but rather a diminution of its direct influence on planning that would improve the quality of planning. A simple way would be to commission external forest experts to draw up plans, which would then have to be approved by the forest authority. In plans compiled in such a way the informal reluctance of the authority as detailed above to define concrete planning targets would come to bear in a less pronounced way. Traditional policy implementation would not from the outset completely limit the planning results, and planning could at least formulate concepts of actually innovative regional planning objectives and measures for discussion.

2) Planning competition instead of planning monopoly by the forest authority.

The most effective means of stepping up the forest authority's planning efforts is to create competition with other forest planning instances. Increasing efforts on the part of nature conservationists to have their own area-wide plans drawn up for forests as well might soon give a new impetus to regional forest planning, because in such a case forest plans would have to reach a quality in terms of regional analysis and the definition of objectives and measures similar to that competitors aim at. Thus the quality of regional forest planning is not enhanced by providing the forest authority with a far-reaching planning monopoly, it is much rather competition with other natural-area-related planning instances that will result in improvements. The forest authority with its wealth of pertinent knowledge, experience and resources would not have to shrink from such competition.

3) Less rather than more public discussion on matters related to regional planning.

The analysis does not confirm the hope that (forest) regional planning would be promoted by a wide public discussion of the issue. The more regional planning is made a public issue, the more it becomes diverted towards symbolic planning, moving away from a target-oriented approach in planning the use of space. On the other hand, if the public shows little interest for issues related to regional planning, symbolical planning loses its impetus. Once this type of regional planning is deprived of its effect, the planning forest authority either would have to give it up or quietly endow it with some more planning objectives. In this sense the low topicality accorded to regional planning by the public at present represents a chance to regenerate it. As explained in item 6, more than just symbolic contact to the public which actually aims at providing information is more easily established on the less intricate local level of public involvement.

4) Information systems instead of futile coordination.

Proposals regarding forests are often frustrated as a result of the failure to coordinate them with the planning of other influential public entities, for example road planners. The results of the analysis show that coordination efforts are necessarily futile for reasons of limited power and that it is more purposeful to exert influence on domains outside of forestry by means of purely factual information as an instrument. A forest planner who illustrates the advantages and disadvantages of a road construction project by means of factual information only will be more successful in practice than a planner aiming at coordinating goals with road planning. While information on a lack of demand or on damaging effects will have an impact in so far as it represents pure information, attempts to coordinate efforts with powerful political entities are doomed to fail as long as their wishes are not completely observed. Consequently forest information systems on all issues of forest use promise a greater impact than coordination, which, starting from a position of weakness, will always remain illusionary.

5) Providing technical solutions instead of restricting the autonomy of forest owners.

As experience shows, forest planning frequently fails on account of forest owners' rights of disposal of their forests as guaranteed in the constitution. However, by drawing up local plans, regional forest planning could contribute to solving conflicts regarding the use of forest space without restricting the autonomy of forest owners. Provided the plan purposes a local distribution of land use claims which benefits all interests, it is sure to be accepted. This kind of technical solutions for the use of forest land can be widely applied. Just take as an example the ecologically most favorable layout of ski slopes in mountain forests or the control of the recreational use of forests bordering on urban areas or in tourist centers. In these examples an appropriate local distribution of uses is of advantage both for the forest enterprises and for the people seeking recreation. Local forest planning could be of great benefit by providing forest owners, people seeking recreation, skiing enterprises, etc. with better information regarding such technical solutions.

6) Pointing out incompatible land use interests instead of futile persuasion.

Not all conflicts of the use of forest land can be solved to the advantage of everybody by technical solutions. In such cases regional forest planning has traditionally attempted to convince all users of the solution judged best from the point of view of forestry. As practical experience shows, such attempts are mostly doomed to fail in the end in spite of great efforts to convince and the compilation of sets of plans of great symbolic impact. A promising alternative consists of clearly illustrating the differences in land use interests in their local context by way of public involvement instead of covering up these differences by plans. The better planning is able to highlight the individual extreme variants of forest-related use of space aimed at by the individual interests, the more the forest authority achieves a middle-of-the-road solution, which it is supposed to aim at anyway in accordance with the laws (Krott 1989 <1>).

This kind of regional planning gives a voice to many victims of regional development sacrificed in the present planning process and, mainly due to this inclusive pluralist representation of all interests, finds support more readily for the necessary compromise between the users of space.

LITERATURE CITED

Arbeitsgruppe Landespflege. 1974. Leitfaden zur Kartlerung der Schutzud Erholungsfunkitonen des Waldes, Munchen.

Becmann, A. 1981. Grundiagen der Planungstheorie und Planungsmethodik, Bern, Stuttgart.

Dons, A. 1967. Inside Bureaucracy, Boston.

Edelman, M. 1976. (deutsche Ubersetzung): Politik als Ritual, Frankfurt/Main.

Klages, H. 1971. Planungspolitik. Stuttgart.

Kohler, V. 1984. Forstliche Rahmenplanung. Natur + Recht 4, S. 121-127.

Krott, M. 1989<1>. Burgerbeteiligungspraxis zwischen Problemen und Entwicklungschancen - 15 Jahre Erfahrungen der US-Forstbehorde in den USA, Osterrelchische Gesellschaft fur Natur- und Umwelt-schutz (Hg.): Praxis der Burgerbeteillgung und Umweltvertraglichkeitsprufung, Wien, S. 11-36.

Krott, M. 1989<2>. Forstliche Raumplangungspolitik. Praxis un Zukunft des osterrelchischen Waldentwicklungsplanes, Wien.

Krott, M. 1990. Die offentliche Verwaltung als umweltpolitischer Problemloser. Ergebnisse einer behordenorientierten Policy-Analyse am Beispiel Waldschutz, Wien.

Peters, B. G. 1984. The Politics of Bureaucracy. New York, London.

Richardson, J. J. and A. G. Jordan. 1979. Governing Under Pressure. The Policy Process in a Post-Parliamentary Democracy, London.

January 10, 1990

DESIGN AND ANALYSIS OF FOREST POLICIES FOR DEVELOPING COUNTRIES

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SUMMARY

Developing countries pose special problems for forest policy design and analysis. Master plans are being made in order to rehabilitate forests in tropical regions. Drawing up these plans is hampered by inadequate data on resources. The implementation of these plans requires consistent forest policies. The design and analysis of such policies is handicapped by uncertainty due to a lack of reliable data on most of relevant economic and social variables. This uncertainty in decision making should be reduced by increasing research into forest and other resources.

Keyword: Policy design, policy analysis, developing countries, forest policy

DEVELOPING COUNTRIES IN THE FOCUS OF FOREST POLICY

Trends in Deforestation and Other Environmental Hazards

The initial situation for forest policy design in developing countries is largely known in a general way, but special problem analyses are required to elucidate the multidimensional nature and extent of the problems.

Deforestation in developing countries, mainly in the tropics, has become a problem of serious universal concern. The annually deforested area is estimated to be 11.3 million ha (Lanly 1982). Apart from ample evidence of deforestation and diminishing possibilities for satisfying the needs for forest products, serious environmental damage and ecological hazards are obvious. Given the present trends in human and livestock populations and land use, and in forest and related policies, desertification, erosion and other degradation of soil will in the foreseeable future make large areas uninhabitable.

It can be logically inferred that the pressure on land increases exponentially as a function of population growth (Riihinen 1986, p. 263-264). With a population growth of 3 - 4 per cent per year in large areas, past policies for the use of natural resources, if continued, are not likely to save the natural environment. Deforestation is associated with a dreadful social problem caused by the fact that the majority of rural people in the tropics have to depend on subsistance agriculture with a minimum of input other than that of labour.

Who is Affected?

For the purpose of policy design and analysis it is desirable first to know who would be affected by the present policies if continued, and by alternative policies if they are adopted.

Deforestation is a problem which tends to affect an increasing number of people. The first ones to face the consequences of deforestation are rural people who depend on forests and woodlands in many ways for their subsistance; forests and woodlands provide sites for agricultural land; pastures, source of fuelwood and other household timber; protection of the environment against eroding agents and desertification; guarantee of the maintenance of genetic resources of fauna and flora. All these services are endangered by deforestation which, while advancing, extends it influences to larger groups in society, both rural and urban. Thus, urban people in certain countries receive their share of the effects of deforestation in the form of floods downstream as a consequence of denudation of mountain slopes upstream.

The degraded rural environment becomes gradually unable to support an increased or even stable population. The pressure is next felt in habitation centres where migrating people struggle for employment and subsistance. Deforestation thus becomes a national problem which tends to affect every citizen. Furthermore, it is believed to affect the climate of the whole world. Even without this gloomy prospect, it would cause hunger and migration with consequences which are already internationally well known.

Forest policy in developing countries should, therefore, be a concern for decision makers not only in developing countries but also elsewhere. The magnitude of the problem justifies no geographical limitation of interest, local governments, international, bilateral and non-governmental organizations.

What Can Be Done:
Emerging Rehabilitation Efforts

One is here dealing with the highest hierarchial level of goalsetting: can the undesirable trend be checked or reversed? If one suspects that the problems have been listed in an unsystematic fashion, there is need to organized the issues to be addressed and sort out the undesirable trends which can be affected.

The social nature of the deforestation problem is well documented, and there is a growing awareness of the ecological hazards due to deforestation in the tropics. However, there was hardly any concerted action until the Tropical Forestry Action Plan (TFAP) was published in 1987. The initiative and coordination was lead by FAO, and practically all the relevant international agencies endorsed the document. TFAP has been accepted by the vast majority of governments. As s consequences, several bilateral development agencies, in coordination with international organizations and governments in the target countries, are preparing both master and action plans for forestry in developing countries. The overall problem has been recognized, but there are specific issues which may require a research contribution.

TFAP aims a halting deforestation, but it is not a technical manual which offers specific remedial measures for all cases. Policy design and analysis is one of the country specific issues that can be addressed only after a careful examination of the deforestation problem in each country. Most often this is done in connection with the drawing up of master or action plans for forestry in developing countries. Using the experienced gained from these plans certain outstanding issues can be dealt with in the framework of theoretical guidelines available from policy science.

GOAL SETTING PROBLEMS

Why is Goalsetting Needed?

Goalsetting in forestry is required for two major purposes: (1) in management planning, for the purpose of selecting a production programme which complies with set profitability (e.g., cost effectiveness) requirements; (2) in policy design and analysis, for the purpose of enabling ex ante and ex post evaluation of a policy, or of alternative policies.

Goalsetting and Non-forestry Objectives

It is taken for granted that in practically all countries goalsetting in forestry is constrained by several social, environmental and other non-forestry objectives. These objectives are in many developing countries so pronounced that it is only because the conventional focus is on forestry that one refers to them as constraints; they equally well be taken us objectives.

Forestry will continue to have its original production and protection objectives, but its increasing role in promoting rural development and the welfare of local populations will gain greater prominence. The aim is not to exploit forests in an effort to create better living conditions for rural people but rather to harmonize land-based activities in a way that promotes an enhanced rural life and more sustainable forestry. The general strategy in halting deforestation consists of efforts to draw people away for subsistance agriculture, on the one hand, and to introduce more rational agricultural practices, on the other. This carries the implication that the major instrument in implementing TFAP is an integrated land-use plan. Another major line of activity is made up of measures designed to develop sources of cash income for rural people in order that they need not depend solely on the land for their livelihood.

Forest policies under such circumstances become multiobjective policies, which may comprise several subpolicies with consistent objectives required to implement the integrated land-use plan. It is advisable for the policy designer to check that there are no mutually conflicting subpolicies in the overall scheme.

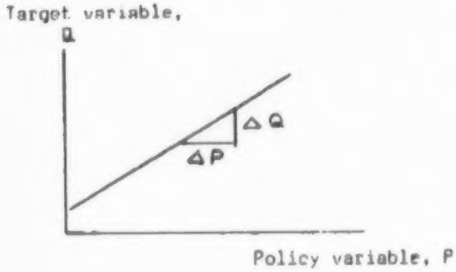
EVALUATION

Introduction to Criteria

Ideally, goalsetting is coupled with evaluation in that, only through evaluation can the ultimate goal be selected from a number of alternatives. Prior to this selection, provisional goals are required, because to evaluate efficiency the inputs required must be estimated on the basis of provisional goals. In this sense the formal process of goalsetting in similar to circular reasoning in that part of the criteria are derived from the goal.

Both ex ante and ex post evaluation usually consists of considering alternative goals in respect of three criteria: (1) effectiveness, (2) efficiency and (3) equity.

Operationally, effectiveness, is the slope of the "effectiveness function" (target variable as a function of policy variable) at a given point:



$$\text{Effectiveness} = \frac{\Delta Q}{\Delta P} = \frac{d(Q)}{d(P)}$$

(Cf. Tinbergen 1975, pp. 53-55; Tikkanen 1981, p.33).

The efficiency criterion aims at comparing the resource allocation properties of alternative policies. The criterion is established by calculating the output/input ratio for each policy alternative. Suppose there are two alternatives policies A and B. For the efficiency of A to better than that of B it is required that either one of the following inequalities be true:

$$\frac{Q_A}{I_A} \qquad \frac{Q_B}{I_B} \qquad \frac{I_A}{Q_A} \qquad \frac{I_B}{Q_B}$$

in which
Q - output of policy
B - input of policy. (Brewer & de Leon, p. 335).

Equity refers to distributional aspects, such as the distribution of income among regions and individuals, of regional employment, or to the distribution of any other desirable social aspect.

As the research methods usually used produce insufficient data, and there is a lack of interest in the development of the forestry sector, it is often difficult even in the developed countries to comply with the theoretical ideals in applying the evaluation criteria. It is nonetheless advisable to use them in guiding the evaluation process, because it is then easier to reach positive conclusions concerning the success or lack of success of the evaluation.

QUANTIFICATION PROBLEMS: SOURCES OF UNCERTAINTY

More Data for Goalsetting

Management planning and policy design and analysis in forestry are still more advanced at the theoretical level than in practice. Relatively few developed countries have information systems which provide adequate data for sustainable quantitative goals in timber production. Countrywide forest inventories, yield studies and management planning are in relatively few countries seen as national priorities which ar worthy of being funded to the level of the most ambitious professional aspirations. The role of forestry and forest industries in the national economy may not be important enough to warrant highly developed information system. More recently, however, attention has turned to forests as an important component of the environment which is being threatened by polluting agents and, therefore, requires follow-up data. Multipurpose forest inventories are gaining importance. Financially, they are hardly prohibitive; e.g., in Finland with 26.8 million ha of forestry land the annually budgets cost for continuous inventory is barely USD 700,000 (1990).

In developing countries, the situation is more complicated. The general aim of halting deforestation requires interpretation, because it is likely to be interpreted differently by different local decision makers. In some countries it may imply maintaining the forest area unchanged, while in others it may be desirable to secure a certain minimum area of production forest and substantial areas of protection forests of a varying degree. Targets may have to be set also for agroforestry and for village forestry as a means of preventing people from cutting down public forests for fuelwood, charcoal and household timber.

Integrated land-use planning implies the coordination of different land uses, all of which may be vital for the subsistance of local people. It is necessary to intensity of production of all commodities and services required, for the land area is finite, while population growth shows no signs of abating.

From the standpoint of the multidimensional goalsetting problem, the inadequacy of quantitative data is obvious. Data on aggregate forest acres are most often obtained from satellite observations, while their distributions by region, species dominance and age class are usually unknown. Total timber volumes are sometimes known only as quesstimates, but their distributions by customary mensurational characteristics are not known. These handicaps tend to apply also to plantations. The need for appropriate inventories and yield studies is urgent, because inputs and outputs in all the activities affected by integrated land-use planning must be based to some degree on goalsetting, the more realistic the better.

The role of goalsetting in forest policy design and analysis cannot be overemphasized as no policy can be better than its goal.

Data for Evaluation

Ideally, a production programme is selected before choosing a policy for the implementation of the programme. a varying degree of thoroughness may be applied to the appraisal by which the programme is selected, the most comprehensive appraisal being based on an input-output analysis of the entire economy. It is recommended as it will account for the total economic effect of the integrated land-use plan and the relevant adjustment of production parameters in many other sectors which are not easily traced in any other way. The analysis of policy efficiency would subsequently benefit form the input-output data. Input-output coefficients, however, may not be available for all developing countries. It should also be noted that there may be difficulties in the measurement of the efficiency criterion to the extent that its value may be affected by factors other than the policy in which one is interested. Strictly, one can speak of policy efficiency only in cases in which causality can be established.

The measurement of effectiveness requires data on goals, on the one hand, and on policy output, on the other. Here, also, one should be able to differentiate the extent to which the output is due to the appropriate policy from that due to other factors.

Following up equity consists of discovering how far a policy has produced the set equity goal, e.g., to what extent employment and income among regions and individuals have been balanced. Here the ex post analysis is identical to the assessment of policy effectiveness.

Challenges to Research

It is obvious that goalsetting for forest policies in developing countries is subject to a great uncertainty because of a lack of relevant data. Management planning at the national level requires a production goal. The possible sources of uncertainty included in this goal are carried over to the forest policy which may thus become less efficient than desirable. Long term bias in forest policy may be caused by misdirected investments which are due to projects chosen on the basis of a biased overall goal.

Development is usually promoted by development projects. Forestry projects are often selected if they have desirable balance of payment effects (reduction of current account deficit). It is well established that an uncommitted additional currency income is an addition to funds which can be invested and is, thus, a macroeconomic benefit.

The deficit of the current account is:
Imports minus exports = domestic investments minus savings

In order to reduce the current account deficit one must reduce investments and/or increase savings. Developing countries have little possibilities for increasing savings in the short term. Investments arc, therefore, the main object of interest and they are usually reduced from the lease profitable end. There must be criteria based on project appraisal to guide the proper selection of investments. To secure unbiased values of these criteria there should be adequate data on outputs, inputs and prices.

As far as data on outputs are concerned, there is a need for yield studies and improving forest inventories. They should also be a partial solution for better input data. There are, however, in most countries, even with developed inventory systems, insurmountable obstacles in establishing an input-output relationship in forestry.

Integrated land-use planning, however, requires data on many outputs and inputs apart from those in forestry. It is not only their present level one is interested in. Ideally, one should be able to predict trends in future productivity and, thus, the levels of outputs, inputs and prices in the future. One may, however, have to replace what is theoretically ideal but not available by what is practically feasible. At the same time, one should take this into account as a source of uncertainty.

LITERATURE CITED

Brewer, G.D. and de Leon, P., 1983: The Foundations of Policy Analysis. Chicago.

Lanly, J.C., 1982: Tropical Forest Resources. FAO. Forestry Paper 30. Rome.

Riihinen, P., 1986: Future Challenges of Forest Policy Analysis. Silva Finnica No. 4/1986, pp. 260-264.

Tinbergen, J., 1975: On the Theory of Economic Policy. Amsterdam - Oxford.

Tikkanen, I., 1981: Causality as a Conceptual Frame for Forest Policy Analysis. Silva Fennica No. 1/1981, pp. 30-37.

THE EFFECTS OF ECONOMIC AND FOREST POLICY ON ROUNDWOOD SUPPLY

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FDC: 903: 923.4: 722.1

SUMMARY

This paper present the main result of the underlying econometric study analysing the factors affecting the demand for Finland. The primary purpose of the study was to analyse the effects of public economic and forest policy means on roundwood supply. Emperical policy analysis gave evidence on that roundwood supply is subject to various sectors of public policy, but the forest policy means proper have not been effective to increase supply.

Keywords: Forest policy, roundwood markets, private forestry

INTRODUCTION

Increasing public control of the management of natural resources has attracted the theoretical interest of policy scientists during the last decades. Simultaneously, along with many social, economic and ecological trends affecting natural resources, it has gained increasing political importance throughout the world. This is due to the fact that actual management of the natural resources deviates from what would be desirable from the national economy point of view and the society as a whole. This deviation may be due to many economic, social and institutional factors. Most often the basic cause is the different time horizon and time preference between the individual and the society.

The political authorities can influence the utilization and development of natural resources by various policy means, by direct control and regulation or by indirect instruments of fiscal, monetary and forest policy or" as usual, employing different co*mbinations of both the direct and indirect policy measures.

In forestry the ultimate object of the control the growing stock. Cuttings and silvicultural measures are at the primary level in the control hierarchy of the growing stock. The Means by which the Political authority influences the cutting and silvicultural behaviour are at the secondary, tertiary, etc. levels because they are designed to influence the cutting and silvicultural investment decision-making of the economic units.

The purpose of the study underlying this paper has been to analyse empirically the effects of economic and forest policy means on roundwood supply in Finland. The main emphasis is laid on the forest taxation policy and the interest rate policy. because of the intensive extension effort made in the Finnish private forestry also its effect is analysed. The effects of the implemented policy on roundwood supply are estimated by means of a simultaneous roundwood market model comprising both the supply and demand. Some main results of the study are presented in this paper, and the outlined theoretical background that has steered the specification of the econometric model used in the estimation. The observation period of the study covers the years 1960-1984 (Tikkanen and Vehkamki 1987).

MODEL SPECIFICATION

In order to specify the model for an empirical study on the effects of economic and forest policy means on roundwood supply a theoretical examination concerning decision-making in forestry and sawmilling industry was carried out. The main outlines of the examination will be presented in the following.

Decision-making on roundwood supply was examined using a farm, comprising two production sectors: agriculture and forestry, as a representative decision-making unit. On the demand side a sawmill was considered. Both the farm and sawmill were hypothesized to be operating under the conditions of perfect competition. For them a decision-making environment was defined by means of:

1) objective function
2) production system
3) decision variables
4) behavioural constraints set by the decision-making unit
5) policy instruments introduced by different authorities
6) price expectations.

The theoretical examination was done as a two-period analysis in order to consider dynamic aspects of decision-making, especially the influence of price expectations.

Decision-making Environment of the Farm

1) The objective of the farm is to maximize the present value of two years' farm surplus.

2) The production system comprises two production relationships: functions for agricultural production and forest growth, and functions for deterioration of the agricultural capacity and the silvicultural level.

3) The farm has four decision variables at its disposal: agricultural and silvicultural investments, roundwood sales and borrowing from the money market.

4) The farm's own behavioural constraints are expressed by means of the terminal conditions on agricultural capacity, growing stock (forest balance), silvicultural level and debt, and by means of the available labor input: no hired labour is used.

5) The farm is acting under the income and property taxation determined by the public authority. For taxation taxable income and property are defined as well as the respective tax functions.The banking sector determines the functions for amortization and interest on the debt, and the function for creditworthiness of the farm.

6) The farm expects that the agricultural product, the roundwood price, and the interest rate on the debt are changing.

Decision-making Environment of the Sawmill

1) The objective of the saw-mill is to maximize its annual profit.

2) The production system is depicted by the following relationships: recovery and cost functions in terms of *sawn wood units.

3) The decision variables are the sales of sawn wood, which determine the purchases of roundwood from farm forests and alternative sources, and borrowing.

4) The mill capacity in terms of sawn wood and the available labour input constrain the operations of the sawmill. The self-financing is restricted by the delivery income, i.e. by the lagged sales income.

5) The operation of the sawmill is subject to the varying exchange rates and credit conditions determined by the Central Bank.

6) The sawnill is not able to speculate with price expectations: any speculative storage is not taken into consideration.

Specification of the Simultaneous Roundwood Market Model

The theoretical examination leads to an abstraction of the real world including the features that are relevant from the point of view of the presented problem. In the model specification, the theoretical variables are operationalized by means of the available time series and the equations to be estimated are chosen.

The model specified from the theoretical examination is presented in a case of a solution where terminal growing stock constraint is binding:

supply function

(1) $Qs(t)= Qs(P1(t),P1(t+1),Pa(t),Pa(t+1),T(t),R(t),X(t),\underline{Y}(t+1),TF(t),DS(t))$

demand function

(2) $Qd(t) = Qd(P(t),Y(t-1),E(t),P1(t),P2(t),U(t),DD(t))$
and

equilibrium condition

(3) $Qs(t) = Qd(t)$

List of variables

Theoretical variable	operationalized variable
1) Qs(t) = Qd(t) Roundwood sales and purchases from farms	1) Sawlog sales and purchases from farms Qs(t) = Qd(t)
2) P1(t) stumpage price level	2) Deflated sawlog price index P(t)
3) P1(t+1) Stumpage price expectations	3) Lagged deflated sawlog price index P(t-1)
4) Pa((t+1) Price expectations of agriculture	4) In the specified model the variable is used to take the price expectations in agriculture into consideration. Price expectations induce the financing need for agricultural investments. In the estimation a proxy Qa(t-1) = Deflated agricultural product is used.
5) R(t) Interest rate of borrowing	5) Deflated average lending rate of saving banks RIR(t), Debt stock change of agriculture and forestry DNL(t) and Marginal interest rate of the Central Bank debt MM(t) are used as proxies in the estimation.
6) T(t) Forest taxation level	6) Deflated and lagged estimated forest tax burden NT(t-1) and Estimated lagged relation between forest tax and net stumpage income TB(t-1)

7) X(t) Forest tax exemption	7) Deflated and lagged forest tax exemption for regeneration areas TX(t-1) and Total deflated and lagged forest tax exemptions XT(t-1)
8) $\underline{V}$(t+1) Growing stock constraint	8) Lagged total stumpage income YS(t-2) describes the previous year's cuttings and the state of the forests.
9) P2(t) Stumpage price of other roundwood purchases	9) Sawlog cuttings of the state forests and forest industry companies SB(t) and Sawlog cuttings of the forest industry companies OF(t+1) are used to describe the substitution effects of the alternative roundwood sources.
10) P(t) Export price of the sawn wood	10) Deflated unit value index of the wood industry export EP(t+1)
11) E(t) Exchange rate	11) Total exchange rate index IER(t) (foreign currencies/Finnish mark)
12) U(t) Unit production cost	12) Unit labour cost of the sawmill industry UC(t)
13) Y(t) Delivery income of the sawmills	13) Total delivery of the sawmills TD(t) including export and domestic consumption of the sawn wood is presented as a proxy.
14) TF(t) Trend factor in the roundwood supply	14) Three different variable alternatives concerning forest management planning of the woodlots are used: Existing management plan stock CMP(t), Management planning MP(t), Management planning with distributed lags DMP(t).
15) DS(t) Dummy-variable of supply	15) Collective agreement on stumpage price DS(t): existed =1, not existed =o
16) DD(t) Dummy-variable of the roundwood demand	16) Demand shock caused by the oil crisis DD(t): year 1975 =1, other years =0

As a result of the theoretical examination hypotheses concerning the effects of the independent variables on roundwood supply and demand in equations (1) and (2) are presented as signs of the partial derivatives as follows:

$$(4)\ \frac{dQs(t)}{dP1(t)} > 0; \quad (5)\ \frac{dQs(t)}{dP1(t+1)} < 0; \quad (6)\ \frac{dQs(t)}{dPa(t)} = 0; \quad (7)\ \frac{dQs(t)}{dPa(t+1)} > 0$$

$$(8)\ \frac{dQs(t)}{dT(t)} = 0; \quad (9)\ \frac{dQs(t)}{dR(t)} > 0; \quad (10)\ \frac{dQs(t)}{dX(t)} > 0; \quad (11)\ \frac{dQs(t)}{d\underline{V}(t)} < 0$$

$$(12)\ \frac{dQs(t)}{dTF(t)} > 0; \quad (13)\ \frac{dQs(t)}{dDS(t)} > 0; \quad (14)\ \frac{dQd(t)}{dP(t)} > 0;$$

$$(15)\ \frac{dQd(t)}{dY(t-1)} > 0; \quad (16)\ \frac{dQd(t)}{dE(t)} < 0; \quad (17)\ \frac{dQd(t)}{dP1(t)} < 0;$$

$$(18)\ \frac{dQd(t)}{dP2(t)} < 0; \quad (19)\ \frac{dQd(t)}{dU(t)} < 0; \quad (20)\ \frac{dQd(t)}{dDD(t)} < 0$$

The signs of the partial derivatives represent the *ceteris Raribl*-effect of the different variables on supply and demand functions. Most of them are self-evident but some phases need explanation. (4) Positive stumpage price expectations cause a negative supply effect: during the rising prices it is profitable to postpone sales. (6) Positive price expectations of agricultural products cause a positive roundwood supply effect through agricultural investment financing. (7) The changes in the acreage taxation of the forests has no supply effect. (9) The forest tax exemptions are supposed to be dependent on cuttings, i.e. on roundwood sales.

STATISTICAL DATA AND ECONOMETRTC METHODS

The empirical policy analysis was based on annual time series data covering the years from 1960 through 1984. The data includes aggregate economic series on forestry and forest industries in Finland. Simultaneous equations of demand for and the supply of sawlogs were estimated using both the two-stage and the three-stage least squares methods. By the 3SLS-estimation the first two stages were based on the reduced form of equations, the third estimation stage employed, in term, the generalized least square method. In the GLS-method the original variables were substituted for transformed variables, $Y^{*}=(Y_t - pY_{t+1})$, by which the possible first-order autoregressive scheme has explicitly been taken into account. To analyse the effectiveness of different economic and forest policy means alternative model specifications were constructed. Only the main results are, however, reported.

Because of the eventual non-stationarity underlying the economic time series used the models were estimated also using first differences of the variables. For the same reason, the autocorrelation functions of error terms with different lags were analysed. Estimated models were evaluated using ordinary economic, statistical and econometric criteria (Harvey 1988, Pindyck and Rubinfeld 1981).

RESULTS

Factors Affecting the Demand for Sawlogs

The estimation results on sawlog demand are summarized in Table 1, where the elasticities measuring the effects of each variable on the quantity demanded together with respective statistics and risk levels denoting the statistical significance of the estimated coefficients are presented.

Estimation results give support to the ex-ante theoretical hypothesis on derived demand as well as on the theory of production and costs. The demand for sawlogs depends strongly on the fluctuations in the prices and quantities in the sawn wood markets. The rising export prices improve the profitability of the industry and expand the processing capacity inducing, thus, the increasing demand for raw wood.

Being export-oriented production, the raw wood demand responses not only to the economic fluctuations in export markets but also to the exchange rate and, hence, to the measures taken by exchange rate policy. Devaluations have increased the demand for raw wood from private forests.

The domestic factor prices of the sawmill industry affect the demand for sawlogs. The impact is depending on whether the changes occur in variable or fixed costs of the production. In the short run, the increase in raw material and partly in labour costs decreases the quantity demanded. The demand is rather inelastic, however, to the stumpage price changes. Labour costs have almost equal affect on demand as the stumpage prices. in general, the production costs seem to have a somewhat smaller effect than the factors related to export markets. In the long run it is obvious that tight monetary policy through high interest rates affects the production capacity and thus decreases the demand.

The increased substitute demand in terms of the cuttings from forest industry's own and state forests will decrease the demand from non-industrial private forests. The substitute demand tends to increase due to the increase in domestic factor prices such as stumpage price.

The estimated demand equation may be evaluated to be satisfactory in terms of economic and econometric criteria.

Table 1. Factors affecting the sawlog demand from non-industrial private forests

Explanatory variable		Elasticity a_i	t	Risk level
P_t -	stumpage price	-0.49	-1.93	0.04
EP_{t+1} -	export price of the wood industry	1.71	4.54	0.00
TD_t -	consumption of sawn timber	1.09	4.98	0.00
UC_t -	labour costs of sawmill industry	-0.32	-1.12	0.14
IER_t -	exchange rate index	-0.73	-3.84	0.00
OF_{t+1} -	cuttings in forest industry's own forests	-0.31	-2.03	0.03
DD_t -	"oil crisis"	-0.40	-2.51	0.01
a_Q -	constant	-3.96	-1.41	0.09

$\bar{R}^2 = .90$ D - W = 2.13

Table 2. Factors affecting the sawlog supply from non-industrial private forests

Explanatory variable		Elasticity b_i	t	Risk level
P_t -	stumpage price	0.68	3.69	0.00
P_{t-1} -	rice expectations	-0.76	-4.19	0.00
YS_{t-2} -	sturapage earnings	-0.21	-1.63	0.06
QA_{t-1} -	gross output of agriculture	1.71	6.27	0.00
RTR_t -	real rate of interest	0.09	3.17	0.00
DNL_t -	change in net loans of farms	-0.09	-2.29	0.02
TX_{t-1} -	tax exemption for regeneration areas	-0.02	-2.59	0.01
TB_{t-1} -	tax base	-0.03	-0.31	0.38
DS_t -	"timber trade "policy"	0.35	4.30	0.00
b_0 -	constant	-12.05	-4.50	0.00

$\bar{R}^2 = .93$ $D - W = 2.10$

Supply of Sawlogs and the Effects of Policy Means

The supply of raw wood from non-industrial private forests is determined mainly by factors related to forest resources, prices, costs, income and the total economy of a forest owner, and his investment and consumption behaviour. Estimation results (Table 2) give evidence on rather inelastic supply in the short run (b1 = 0.7). The long run total price effect, when taking the price expectations into account, approaches a perfectly inelastic supply. As a part of the total economy of the owner, the supply behaviour adapts itself to the income and financing aims and the growing stock constraints varying along with time. Therefore the strong interdependency between raw wood supply and agricultural production can be explained by investment behaviour. Part of the farm investments are financed by stumpage income.

The money markets and monetary policy form an external economic basis for the decision-making concerning investments in the farm and its financing. Low real interest rates (high inflation) and loose money markets (increasing supply of loans) are likely to lead to a decreasing timber supply. Stumpage income is then to be substituted for increasing borrowing.

The effects of forest taxation as a policy means were analysed in terms of the level of taxation (tax base) and the tax exemptions used to stimulate timber growing. An area based, assessed average yield taxation system seems to be quite neutral, as expected, to a cutting decision. In addition, tax exemptions, mainly designed to stimulate forestry investments as a function of cuttings, do not cause any significant short term effects on timber supply.

Forest management planning has been employed as a main tool of public forest policy to increase timber growing and cuttings. Planning has evidently some positive supply effects, but, however, seemingly less than expected.

Timber trade policy in terms of stumpage price recommendations and attempts to steer the quantities to be supplied has had positive effect on sawlog markets.

POLICY IMPLICATIONS

Theory based, empirical policy analyses contribute to the rational and better design, decision-making and evaluation of public policies affecting the management of forest resources. To meet the aims of balanced growth of forest industries we may need measures of economic, forest and timber trade policies which influence both the demand for and supply of roundwood.

In addition to the steering of investments in production capacity the demand can be affected through exchange rate policy and the prices of production factors. The total effectiveness of controlling the prices of production factors - stumpage prices, labour costs and interest rate - can be evaluated to be stronger than the impacts of devaluations.

Because the projected demand for raw wood is increasing worldwide, the major policy concern and emphasis should be in formulating supply stimulating policy programs. Here the policy design is primarily dependent on the price elasticity of supply. In case of inelastic supply the policy interest should be directed to those instruments which are effective enough to shift the supply as desired. The analyses carried out above suggest, however, that single means of forest policy proper have had only minor effect on the short run supply behaviour of NIPF-owners. This is mainly due to the fact that public forest policy in Finland, as in many other countries, too, is directed to stimulate long term timber growing investments rather than short run supply. Policy means included in such major forestry policy areas as forest taxation and forest management planning have not, thus, been effective. Therefore, policy development towards more supply-oriented policy contents is required.

An effective policy program would also presuppose a combination of parallel measures of fiscal, monetary, agricultural and forest policy. Because of the ratlier low priority of forestry in political decision-making at present, the measures taken in different sectors of public policy may result even in contradictionary effects in forestry.

LITERATURE CITED

Harvey, A.C., 1988: The econometric analysis of time series, Oxford.

Pindyck, R.S. and Rubinfeld, D., 1981: Econometric models and econometric forecasts. Second edition. New York.

Tikkanen, I. and Vehkamaki, S., 1987: Yksityismetsien havutukkien kysynta ja tarjonta. Demand for and supply of sawlogs from private forests in Finland: Preliminary report on econometric analysis of sawlog markets and forest policy. University of Helsinki, Dept. of Social Economics of Forestry. Research reports No. 14. 1987.

FOREST POLICY AND ADMINISTRATION RESEARCH: POTENTIAL DIRECTIONS FOR THE FUTURE

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SUMMARY

FDC: 903: 932

The scope of policy development has broadened significantly, requiring the talents of a variety of social, managerial and institutional sciences. To be most effective in the years ahead, policy and administration research should strategically focus on improving the forestry community's understanding of the processes by which policies and programs are developed, the participants involved in the development of forest resource policies, the means by which the use and management of forests are planned, the budgeting and fiscal processes important to forestry, and the innumerable public programs which are focused on the use and management of forests. In addition, researchers should be actively involved in the evaluation and analysis of appropriate forestry issues.

Key Words: Policy process, policy institutions, policy programs.

INTRODUCTION

The development of policies and programs focused on forest resources throughout the world has grown in complexity in recent years. Likewise, the number of disciplines and the number of organizations expressing an interest in the use and management of forests has also expanded. Indeed, the conceptual foundation for policy development has broadened considerably. No longer is economic efficiency a pervasive criterion for judging the merits of forest policies -- institutional arrangements, distribution of benefits, and consensually determined standards are often of paramount concern. Furthermore, policy and program development is no longer the task of the few. Interest groups, the media, the general public, and judicial and legislative systems are actively involved in the development of policies. The social science disciplines from which are drawn the conceptual foundations for the development of policy have also expanded -- law, sociology, and political science offer significant insight into the development of forest policies. The agenda for future research focused on policy development and program administration must reflect the broadened disciplinary and institutional interests in how forest policies are developed and implemented. To be useful, strategic research directions concerning policy development and program administration would be most appropriate if focused on acquiring knowledge in the following major topical areas (Ellefson 1989):

* Processes by which forest resource policies are developed.
* Participants involved in the development of forest resource policies.

* Budgetary and fiscal investment processes germane to forest resource programs.
* Planning the use and management of forest resources.
* Public program initiatives focused on the use and management forest resources.
* Efficiency, effectiveness, and distributional consequences of major forest policy issues.

DEVELOP IMPROVED UNDERSTANDING OF PROCESSES BY WHICH FOREST RESOURCE POLICIES ARE DEVELOPED

The development and application of forest resource policies to issues of technical and social importance are ongoing activities that involve individuals as well as organizations. Such activities can usually be grouped into a consistent pattern of events which in total compose the process by which policies are developed and implemented. Comprehensive research designed to improve the process has been limited within the forestry community. Researchers are prone to focus on the product of the process (i.e., a specific forest policy); few have researched opportunities for making the process more efficient and, subsequently, the policy product more appropriate. To effectively carry-out such research implies an appreciation of policy development as a political activity -- a political activity that involves the exercise of power and persuasive tactics, involves intense struggle over values and preferences, surfaces interest in identifying those who will impede (or aid) the adoption of proposed policies, and is concerned over individuals and organizations that are likely to gain or lose if a particular policy is adopted. Such is the reality of politics.

Research topics concerning the effectiveness and efficiency of policy development and implementation include the following.

Evaluate effectiveness of agenda-setting processes germane to the development of forest policies. Policies and programs are developed in response to problems and issues surfaced by individuals and organizations. Often, issues and problems of immediate concern overshadow less apparent though equally important longer-term concerns. Lacking efficient agenda-setting processes, socially important issues may not be recognized and progressive forest policies are unlikely to surface. How effective are existing agenda-setting procedures (e.g., identification of national issues)? What shapes local, state, and national forestry agendas? What is the nature of persons and organizations involved in agenda-setting processes? How important are political moods of the electorate and political windows of opportunity? Why are certain issues diverted, deferred, or displaced? Under what circumstances are issues ignored and agenda status obstructed? And how can less immediate problems be brought to the attention of policy makers and those who influence them? Except for modest attention to public involvement processes, very little research has been devoted to agenda setting as a strategic process involving forestry topics (Davies 1974, Ellefson 1990). There exists a rich conceptual base from which to undertake such research (Cobb and Elder 1983, Eyestone 1978, Kingdon 1984).

Assess effectiveness of processes by which forest policies are formulated. Once an issue has been successfully placed on an organization's agenda, the process must turn to identification and evaluation of objectives, policies, and programs that are capable of addressing the issue (i.e., formulation). How effective are formulation processes and how might they be improved? Who is -- and is not -- involved in the formulation process and from where do ideas for policy options arise? Research focused on the formulation of forest policies and programs is almost nonexistent. The theoretical foundation for formulation is also sparse (Bryner 1984, Polsby 1984).

Evaluate alternative means by which forest policies are selected. Displaying the consequences of alternative forest policies is one thing -- selecting from amongst the alternatives is another. Many researchers (especially forest economists) continue to be of the opinion that the rules of economic efficiency and rational comprehensive approaches prevail in the selection process. Such is highly unlikely. What is the context within which policies are selected, and how can selection processes -- within a political environment -- be improved? How appropriate are current selection models to forestry decision environments -- rational comprehensive, rational incrementalism, mixed scanning, and organized anarchy? How important is personality and information to forestry decisions, and under what circumstances is group rather than individual decision making more appropriate? What should be the nature and application of strategies and tactics involving bargaining, negotiation, and mediation? And under what circumstances should criteria of various sorts be employed to make judgments about competing policy alternatives (e.g., criteria such as technical-ecological, efficiency-effectiveness, equity-ethical, values-ideologies, procedural). Research on the relative efficiency and effectiveness of policies and programs has a lengthy history within the forest economics community. However, a broader perspective involving non-economic criteria is sorely needed. The conceptual bases for such research is abundant (Bass 1983, Cohen et al. 1972, Lindblom 1959, Reitz 1987).

Evaluate means by which forest policy choices are legitimized. Forest policies may be viewed as desirable, may be agreed to, and may be selected. But selection is no guarantee of implementation and ultimate attainment of laudable goals. Policies must be given some official status -- legitimized in a law, a plan, a regulation, a judicial ruling. How are forest policies legitimized and what forms of legitimacy are more effective than others (e.g., law versus agency regulation)? What role does political feasibility play in the legitimizing of forest policies? Specifically, what type of information about political feasibility would be useful under what circumstances (e.g., potential opponents, power base of opponents)? And what is the relative efficiency of various strategies and tactics used to secure legitimacy of a forest policy (e.g., compromise, logrolling, side-payments)? Formal research on such questions is virtually nonexistent within the forestry community (Ellefson et al. 1981). Unfortunately, the conceptual foundations for such research have yet to be fully developed (Bryner 1984, May 1986, Meltsner 1972).

Assess processes by which forest resource policies are implemented. Implementation of agreed to policies is a most critical step in the policy process. All too often, the forestry community is reminded of the law that failed to meet user expectations or the forest plan that "remained unimplemented on the shelf." Why do policies and programs fail in the implementation stage, and how might the process be made to function more efficiently? Are there problems in organizing the bureaucracy for implementation purposes (e.g., limited financial resources, limited professional talent)? Are laws and regulations being properly interpreted into feasible directives that will achieve widely agreed-to objectives? And what about follow-through -- the routine provision of services, payments, and obligations? Research on the implementation of forest resource policies per se is sparse (Harper n.d.). In the United States, National Forest System plans are replete with implementation procedures. They represent an especially fertile source of hypotheses for implementation research. Conceptual foundations for implementation research are significant (Bardach 1982, Ripley and Franklin 1982, Scheirer 1981).

Assess means of evaluating forest resource policies and programs. Properly conceived, evaluation is an activity which can make substantial contributions to understanding and improving policy development and implementation. Most evaluations, however, have focused on economic efficiency concerns. Needed is a more broadly based perspective of policy and program worth. (Why, for example, does a program continue to be implemented, even though weighty evidence demonstrates its inefficiencies)? What other mechanisms play a role in evaluation and control of forest resource programs (e.g., legislative and interest group oversight, internal auditing and accounting) and how effective have they been? Through research, might they be designed so as to more effectively facilitate the judging of a policy's pros and cons? For systematic evaluations of program efficiency, what procedures (e.g., project analysis, sector analysis), criteria, and analytical tools are most appropriate? What motivates interest in evaluation (e.g., justification, program change)? Who are (and should be) the clients of evaluation processes and what informational products are desired from an evaluation? Why is there resistance to evaluations? And what role should policy analysts play in the evaluation process (Ellefson 1986a)? Forest economists have a long standing tradition of evaluating the efficiency and effectiveness of forestry programs (e.g., fiscal incentive programs, fire management programs, nondeclining-evenflow timber management programs, forest planning programs, below-cost timber sale issues) (Risbrudt and Ellefson 1983, Gray and Ellefson 1987, Henly and Ellefson 1986). Research of such a nature has been useful to program administrators -- but certainly is deserving of more broadly defined concepts of evaluation. The latter are readily available for testing in a forestry context (Datta and Perloff 1979, Abt 1976).

Evaluate processes by which forest resource policies and programs are terminated or succeeded. Termination of policies and programs is a logical -- but much neglected -- phase in policy development cycles. Interest in the subject has increased in recent years for a number of reasons, including concern over how a program should be ended if the logical outcome of an evaluation suggests termination, or if budgetary retrenchment dictates the cessation of a program (e.g., mandated by a change in political leadership or economic conditions). Seldom are programs completely terminated -- some replacement is normally provided.

But what should be the nature of efficient processes for termination of programs that are judged to be lacking? What difficulties arise in efforts to terminate programs and how might they be effectively addressed (e.g., legal obstacles, high start-up costs)? How can policies and programs be designed for termination, especially when the policy issue to be addressed has a well defined time dimension, or when termination is expected because of pending changes in economic and political conditions? Research on the termination of forestry programs is almost nonexistent. Such an information void suggests that when termination is immanent, procedures for doing so are likely to be traumatic and less than efficient. Unfortunately, conceptual frameworks for researching program termination are also sparse (Brewer and de Leon 1983, Hogwood and Gunn 1986).

ACQUIRE A MORE DISCERNING UNDERSTANDING OF PARTICIPANTS INVOLVED IN THE DEVELOPMENT OF FOREST RESOURCE POLICIES

The process by which forest policies and programs are developed and implemented is an important focus for research -- it cannot, however, be divorced from the actors or participants who make the process operate. For example, although a policy may be legitimized by a court, administrative response to such an action will be less than effective if legal and judicial processes are not well understood. Similarly, organized interest groups may resist adoption of a policy, but the nature of such resistance will not be appreciated until the objectives, structure, and operation of interest groups are adequately understood. Implied, therefore, is the need for substantial research focused on participants in the policy development process, especially legislatures, courts, interest groups, bureaucracies, and related organizations.

Evaluate the role of legislative systems in the development and implementation of forest resource policies. Legislative systems are a major source of forest resource policies; hence, the manner in which they operate in a forestry context is especially important. Research questions to be posed can be nearly unending. How are legislatures organized to address matters of forest policy and how might they be structured more effectively to do so (e.g., committee structure, staff, specialized offices)? What is the work flow of legislators, and how can forestry interests be facilitated in such an environment? What is the nature of legislative decisions regarding forestry topics, and how might strategies toward consensual decision making be enhanced when forestry issues are addressed? What is the nature of forestry information flows to legislative systems, especially the type of information required, the source of such information, and the means by which it is provided (e.g., legislative hearings, special commissions, bureaucratic or legislative staff)? What is the nature of legislative staff and what role does it play in a forestry context? And what role do legislative systems play in each of the major steps involved in the development and implementation of forest policies (i.e., agenda setting, formulation, selection, legitimizing, implementation, evaluation, and termination)? Forestry research focused on legislative systems is limited (Council of State Governments 1985, Gray and Ellefson 1987, Ellefson et al. 1981, Ellefson 1985). That which does exist focuses primarily on historical accounts of the political labyrinth through which forest policies have passed on their way to becoming law. Needed is research of a more functional orientation. The conceptual basis for doing so is exceptionally abundant (Bradley 1980, Hammond 1985, Muir 1982).

Assess the role of judicial systems in the development and implementation of forest resource policies. The judiciary has had substantial impact on the course of American forestry in recent years. The laws that have been interpreted and the rulings that have been issued have often been nothing short of revolutionary. Ironically, relatively little systematic research has been focused on the judiciary from a forestry perspective (Dall 1989). Again, research questions to be raised are nearly endless. What is the fundamental structure of local, state, and federal judicial systems that makes such systems so influential on matters of forestry? Over what subjects does the judiciary have jurisdiction and what is the nature of forestry issues that are likely to appear on judicial agendas? Under what conditions do forestry interests have standing in the eyes of the courts, and what circumstances foster class-action suits? What is the nature of forestry information utilized by the judiciary -- what kind, what source, and what quality? To what extent do courts make policy and how do they do so -- by reinterpreting laws or constitutions, designing administrative remedies, extending reach of existing law to subjects not previously covered? Should some decisions be excluded from judicial review? How can the forestry community facilitate the actions of judicial systems? And what role does the judiciary play in the various steps leading to the development and implementation of forest resource policies (i.e., agenda-setting, formulation, selection, legitimizing, implementation, evaluation, termination)? Again, forestry research focused on judicial systems has been slim. That carried out has focused on case-by-case reviews of the implication of rulings directed at specific issues. Research focused on judicial processes in a forestry context is very much lacking. As might be expected, the conceptual foundation for such research is especially abundant (Glick and Vines 1973, McLauchlan 1977, Sax 1970).

Evaluate the role of organized special interest groups in the development and implementation of forest resource policies. Organized interest groups active in matters of forest policy have proliferated in recent years. Likewise, their influence on the nature of forest policies has flourished -- to the point of becoming an advocacy explosion. The forestry community has not been totally comfortable with interest groups. Understanding interest group operations and facilitating their involvement in policy development has substantial merit. For example, what is the nature of the interest groups that are relevant to the forestry community (e.g., what groups, how large financially, extent of membership)? What forestry issues are likely to bring forth the involvement of interest groups (e.g., subjects of concern, geographic limits on activities)? In what fashion are interest groups governed and operated? How can they be designed to be administratively more effective? Who governs interest groups and by what means are decisions attained? What is the nature of interest group influence and how can it be organized to the betterment of consensual decision making on matters of forestry? What is the nature of lobbying activities and how can such activities be made more effective within the forestry community? How can the financial and staffing difficulties of interest groups be overcome? And how can organized interest groups become more effective in each of the major steps involved in the development and implementation of forest policies (i.e., agenda setting, formulation, selection, legitimizing, implementation, evaluation, and termination)? Research concerning organized interest groups of importance to the forestry community has been modest -- much remains to be accomplished (Culhane 1981, Ellefson 1986b). In recent years, the conceptual framework for such research has increased substantially (Berry 1984, Ornstein and Elder 1978).

Evaluate the role of bureaucratic systems in the development and implementation of forest resource policies. Bureaucracies are the means by which most forest resource policies are implemented, evaluated -- and often proposed. They are the cohesive force which leads to specific accomplishment of some desired forestry objective. The number of bureaucracies (e.g., state and federal pollution control agencies) and their complexity has grown substantially in recent years. Ironically, very little research has been focused on how forestry and related organizations should be structured and staffed in order to achieve legislative or judicial mandates. How should forestry organizations be structured in terms of labor, authority, and departmentalization? What structures would facilitate communication, decision making, and performance evaluation? How can administrators facilitate intergroup behavior and manage conflict more effectively? What is (and should be) the relationship between politics and administration and between ethics and public service? And what structural and managerial actions will facilitate the often unique relationship that exists between public and private management of forests and forest resources? Research focusing on questions of such a nature has lead to a number of classic studies involving the administration of forestry and related organizations (Haskel and Price 1973, Kaufmann 1967, Robinson 1975). The conceptual basis for such research exists throughout extensive literature on organizations and their administration.

Evaluate the role of the media, political parties, and related organizations in the development and implementation of forest resource policies. Journalistic interest in the use and management of forests is keen, yet it is often overwhelming to forest resource professionals. Media interpretation of forestry issues can have a substantial effect on public perceptions of forestry, forest policies, and the forestry profession. Most certainly there is a need and an opportunity for research that would lead to a better understanding of journalistic interest in and effects upon forest policies and programs. Similarly there are other organizations that deserve attention from a forestry perspective (e.g., political parties).

ACQUIRE IMPROVED UNDERSTANDING OF BUDGETARY AND FISCAL INVESTMENT PROCESSES GERMANE TO FORESTRY PROGRAMS

The production of goods and services by forests often requires the investment of land, labor, and capital over unusually long periods of time. Rotation lengths of 100 or more years are not uncommon for the production of timber. Similar time periods are often required to produce the aesthetically pleasing landscape so often demanded by the forest recreationist. The development of wildlife habitat may also require extended periods of time as do many long-term forestry research activities. Because of forestry's often unique requirements for extended periods of time, the need for long-term, sustained levels of investment in forestry and related programs are essential. Financial and professional commitment cannot be erratic if the flow of forest outputs is to have uniformity or sustainability. The problem becomes especially acute during times of austere public budgets. Much neglected by the research community, however, are budgeting and fiscal investment processes. Needed is a concerted effort to understand existing budgetary processes and to develop processes that can accommodate the unique conditions which surface in the management of forests. For example, exactly what difficulties do forestry programs face because of the manner in which budgeting cycles operate? How do budgets and fiscal exigencies influence forest policies and programs? Are their alternative revenue sources more accommodating of the public's interest in forests and how effective have they been (e.g., user fees, bonding programs, private loans)? What problems arise because benefits of the forest are often non-market in nature; how might such problems be addressed in the process of allocating scarce public funds? Are forest planning processes linked to budgeting processes? If not, how can such be effectively accomplished? What impact do managerial sciences (e.g., economics) have on budgetary processes and, if deemed desirable, how can they be made to be more influential? And are there cumbersome administrative reviews of proposed budgets that could be streamlined to encourage greater efficiency? The problems of budgeting and fiscal accounting are significant in a forestry context. They are deserving of research attention (Schultze 1968).

DEVELOP MORE EFFECTIVE MEANS OF PLANNING THE USE AND MANAGEMENT OF FOREST RESOURCES

Planning the use and management of forest resources has become an especially important activity of government forestry organizations. Fostered by an abundance of recently established laws in countries throughout the world, planning programs have enabled forestry interests to more clearly define agreed to forestry objectives and have enabled forestry professionals to develop forestry programs that are capable of accomplishing such objectives more effectively. The relative newness of comprehensive program and land management planning activities has surfaced a number of planning issues that are deserving of research attention. Such issues do not involve the substance of the plans that are produced; they concern the efficiency and effectiveness of the processes used to produce plans and the administrative uncertainties implied therein. Research on such topics has been very limited within the forestry community (Ellefson 1984, Gray and Ellefson 1987); conceptual foundations are also meager (King 1983).

Evaluate planning objectives and commitment. Planning involves investment of scarce resources. What fundamental purposes are served by planning activities? If benefits are expected, what is their nature and what client groups are likely to receive them? If planning is deemed to be important, what mechanisms can be used to secure agency commitment to planning activities (e.g., legislative directive, agency regulation, professional interest, non-governmental pressure)? And in order to maintain their relevance to the forestry community, how should the effectiveness of planning programs be judged?

Assess alternative planning processes. Planning can employ any one of many procedures. Should the process rely on issue-driven mechanisms, goal-driven mechanisms, or some other approach? How can planning processes be designed so as to accommodate unforeseen events (e.g., change in political leadership)? What is the most effective means of integrating planning processes with other governmental processes (e.g., budgeting, implementation, feedback processes)? And what forest resources (e.g., single- versus multiple-uses), functions (e.g., roads versus fire management), and ownerships (e.g., public versus private) should planning processes be designed to accommodate?

Evaluate resources required to plan. Financial and related resources are consumed by planning activities. Under varying circumstances, what financial commitments are required to carry out planning activities? Are there economies of scale to be captured in the design of planning programs? From what source will financial support originate (e.g., planning unit, fees from serviced unit)? And what type and how much professional talent should be invested in planning activities? And are the investments made in planning worth the benefits obtained?

Assess administrative structure for planning. What unit(s) of government should be responsible for planning (e.g., regional versus national units, planning within functional units, operationally integrated versus independent planning unit)? What agencies should provide input to planning activities (e.g., natural resource, economic development, pollution control, universities)? At what level should such agencies be involved (e.g., chief executive staff, department level, division level, field level)? How can coordination of planning within an agency and among agencies be most effectively accomplished? And who at what level is to decide if a plan is acceptable -- and by what criteria?

Evaluate public involvement processes. Planning public forestry programs implies accommodation of public desires for the products and services of such programs. What techniques are most effective for securing client and public perspectives on the use and management of forests? What portion of the total planning budget should such activities consume? If the public is to be involved in the planning process, how should such involvement take place (e.g., asked for help, briefed on progress, comment on results)? And what is the most effective means of integrating public input into the preparation of a plan?

Assess information management procedures. Planning activities require the use of much information. What type of information is necessary for the development of plans? How can such information be most effectively generated; who should supply it; and when should it be made available in the planning process? What type of commitment to information management will be required? And should an information management system be unique to a planning effort or should it be designed to serve other purposes (e.g., program budgeting)?

Evaluate implementation and monitoring. What forms of commitment are most effective for securing the implementation of forestry plans (e.g, policy statements)? Who should impose requirements that plans be implemented -- legislative directive, administrative rules, interest group pressure? How can plans be effectively integrated with budgeting processes? What flexibility should be built into plans in order to accommodate unforeseen events such as new technologies and new and more reliable information? In what manner are added budget constraints resulting from economic downturns to be addressed? And how is changing program emphasis due to changes in political leadership to be accommodated?

DEVELOP MORE EFFECTIVE PUBLIC PROGRAM INITIATIVES FOCUSED ON THE USE AND MANAGEMENT OF FOREST RESOURCES

Public forestry programs focusing on private forestry activities are substantial in number and in importance. They are subject of continuing analysis and evaluation -- a healthy process that fosters efficiency and effectiveness. Such assessments should occur on a continuing basis and should accommodate technological advances in evaluation procedures.

Evaluate information and service program initiatives. There exists a variety of information and service programs at federal and state levels (e.g., forestry extension, service forestry, research). The effectiveness and efficiency of such programs have been assessed in the past, often resulting in positive administrative responses to improve program design and focus. Evaluations of this sort should continue.

Assess fiscal subsidies and tax program initiatives. Fiscal subsidies designed to encourage the management of private forests have been a significant world-wide activity (e.g., cost-share programs). Likewise, tax policies and programs designed to encourage the production of forest products have been met with considerable favor by the forestry community (e.g., property tax initiatives, capital gain treatment of income from the sale of timber). Except for tax initiatives, such programs have been subject to considerable evaluation (Risbrudt and Ellefson 1983). Tax policies are in need of rigorous evaluation in the spirit of designing tax policies that efficiently achieve public objectives in private timber management.

Evaluate regulatory actions focused on the use and management of forests. Regulatory programs focused on the management of forests and the products and services produced by forests have grown significantly in recent years. In the United States, for example, many states have developed programs to legally regulate the forest management activities of private landowners, under the presumption that regulatory programs are more effective than other programmatic alternatives (e.g., extending information, fiscal subsidies, government ownership). Unfortunately, economic evaluations of regulatory programs are few (Henly and Ellefson 1986). They are certainly deserving of research attention -- again in the spirit of designing more efficient programs to meet a variety of public interests.

EVALUATE THE EFFICIENCY, EFFECTIVENESS AND DISTRIBUTIONAL CONSEQUENCES OF MAJOR FOREST POLICY ISSUES

Forest policy issues of national and regional importance arise on a continuing basis. Social science researchers often have much to contribute to the resolution of such issues -- indeed, they have a responsibility to do so. Not only can such researchers contribute to the substance of debates over forest policy but their involvement also often entails opportunity to try untested analytical procedures and processes -- all to the betterment of future analyses. Social science researchers should continue their role in assessing the implications of a wide array of issues -- ranging from atmospheric pollutants to international trade and from below-cost timber sales to public land wilderness management.

SUMMARY AND CONCLUSIONS

The development of forest resource policies and the administration of programs designed to implement such policies has increasingly become acknowledged as an important area of research. In recent years, however, the scope of the policy development arena has been significantly broadened, requiring the talents of a variety of social, managerial and institutional sciences. To be most effective in the years ahead, policy-type research should strategically focus on improving the forestry community's understanding of the processes by which policies and programs are developed, the participants involved in the development of forest resource policies, the means by which the use and management of forests are planned, the budgeting and fiscal processes important to forestry, and the innumerable public programs which are focused on the use and management of forests. In addition, researchers should be actively involved in the evaluation and analysis of appropriate forestry issues. All such activities should be undertaken in the spirit of developing more effective policies and programs focused on the world's public and private forests.

LITERATURE CITED

Abt, C. C. 1976. The Evaluation of Social Programs. Sage Publications. Beverly Hills, CA.

Bardach, E. 1982. The implementation game: What happens after a bill becomes a law? MIT Press. Cambridge, MA.

Bass, B. M. 1983. Organizational decision making. Richard D. Irwin Publishers. Homewood, IL.

Berry, J. M. 1984. The interest group society. Little, Brown and Company. Boston, MA.

Bradley, R. B. 1980. Motivations in legislative information use. Legislative Studies Quarterly 5(3):393-406.

Brewer, G. D. and P. de Leon. 1983. The foundations of policy analysis. The Dorsey Press. Homewood, IL.

Bryner, G. C. 1984. Regulatory rule making and the process of policy formation. In: Public policy formation by R. Eyestone (ed.). JAI Press. Greenwich, CN.

Cobb, R. W. and C. D. Elder. 1983. Participation in American politics: The dynamics of agenda-building. Johns Hopkins University Press. Baltimore, MD.

Cohen, M., J. March and J. Olsen. 1972. A garbage can model of organizational choice. Administrative Science Quarterly. 17(March): 1-25.

Council of State Governments. 1985. Forestry in the South: A survey of state legislative and executive roles and information needs. Lexington, KY.

Culhane, P. J. 1981. Public lands politics: interest group influence on the Forest Service and the Bureau of Land Management. Johns Hopkins University Press. Baltimore, MD.

Dall, B. V. Forest resources law and legal processes: Potential research directions. P. 303-314. In: Forest resource economics and policy research: Strategic directions for the future. P. V. Ellefson (ed.). Westview Press. Boulder, CO.

Datta, L. E. and R. Perloff. 1979. Improving evaluations. Sage Publications. Beverly Hills, CA.

Davies, J. C. 1974. How does the agenda get set? In: The Governance of common property resources by E. T. Haefele (ed.). Johns Hopkins University Press. Baltimore, MD.

Ellefson, P. V., J. O'Laughlin and R. A. Skok. 1981. Minnesota timber development options: A classification of alternatives contained in the Legislative Commission on Minnesota Resources timber development study. Station Bulletin 543 (Forestry Series 38). Agricultural Experiment Station. University of Minnesota. St. Paul, MN.

Ellefson, P. V. 1984. Organizational patterns and administrative requirements for development of forest plans: The case of state governments in the United States. Proceedings of IUFRO symposium on forest management planning and managerial economics. Tokyo, Japan.

Ellefson, P. V. 1985. Congressional testimony: Who presents wood-based industrial interests? Journal of Forestry 83(5):300

Ellefson, P. V. 1986a. Decisions about public forestry programs: The role of policy analysts and analytical tools. Journal of Resource Management and Optimization 4(1):65-77.

Ellefson, P. V. 1986b. Forestry and related political action committees. Journal of Forestry 84(5):20-26.

Ellefson, P. V. (ed.) 1989. Forest Resource Economics and Policy Research: Strategic Directions for the Future. Westview Press. Boulder, CO.

Eyestone, R. 1978. From social issues to public policy. John Wiley and Sons. New York, NY.

Forest Service. 1981. Alternative Goals. 1985 Resources planning Act Program. Program Aid No. 1307. U.S. Department of Agriculture. Washington, DC.

Forest Service. 1986. Resources planning act program 1985-2030: Final environmental impact statement. FS 403. U.S. Department of Agriculture. Washington, DC.

Glick, H, R. and K. N. Vines. 1973. State court systems. Prentice-Hall. Englewood Cliffs, NJ.

Gray, G. J. and P. V. Ellefson. 1987. Statewide forest resource planning programs: An evaluation of program administration and effectiveness. Bulletin 582. Agricultural Experiment Station. University of Minnesota. St. Paul, MN.

Hammond, S. W. 1985, Legislative staffs. In: Handbook of legislative research by G. Loewnberg, S.C. Patterson and M.E. Jewell (eds.). Harvard University Press. Cambridge, MA.

Harper, J. (no date). A model for implementation of a statewide forest resource plan. Division of Forestry. Minnesota Department of Natural Resources. St. Paul, MN.

Haskell, E. H. and V. S. Price. 1973. State environmental management: Case studies of nine states. Praeger Publishers. New York, NY.

Henly, R. K. and P. V. Ellefson. 1986. State forest practice regulation in the U.S.: Administration, cost and accomplishments. Bulletin AD-SB-3011. Agricultural Experiment Station. University of Minnesota. St. Paul, MN.

Hogwood, B. W. and L. A. Gunn. 1986. Policy analysis for the real world. Oxford University Press. Oxford, England.

Kaufman, H. 1967. The forest ranger: A study in administrative behavior. Johns Hopkins University Press. Baltimore, MD.

King, W.R. 1983. Evaluating strategic planning systems. Strategic Planning Journal 4:263-277.

Kingdon, J. W. 1984. Agendas, alternatives and public policy. Little, Brown and Company. Boston, MA.

Lindblom, C. E. 1959. The science of muddling through. Public Administration Review. 19(2):79-88.

May, P. J. 1986. Politics and policy analysis. Political Science Quarterly 101(1):109-125.

McLauchlan. W. P. 1977. American legal processes. John Wiley and Sons. New York, NY.

Meltsner, A. J. 1972. Political feasibility and policy analysis. Public Administration Review 32 (November/December).

Muir, W. K. 1982. Legislature: California's school for politics. The University of Chicago Press. Chicago, IL.

Ornstein, N. J. and S. Elder. 1978. Interest groups, lobbying and Policymaking. Congressional Quarterly Press. Washington, DC.

Polsby, N. W. 1984. Political innovation in America: The politics of policy initiation. Yale University Press. New Haven, CT.

Reitz, H. J. 1987. Behavior in organizations. Irwin Publishers. Homewood, IL.

Ripley, R. B. and G. A. Franklin. 1982. Bureaucracy and policy implementation. The Dorsey Press. Homewood, IL.

Risbrudt, C. D. and P. V. Ellefson. 1983. An economic evaluation of the 1979 forestry incentives program. Bulletin 550. Agricultural Experiment Station. University of Minnesota. St. Paul, MN.

Robinson, G. O. 1975. The Forest Service: A study in public land management. Johns Hopkins University Press. Baltimore, MD.

Sax, J. L. 1970. Defending the environment: A strategy for citizen action. Alfred A. Knopf Publishers. New York, NY.

Scheirer, M. A. 1981. Program implementation: The organizational context. Sage Publications. Beverly Hills, CA.

Scultze, Charles L. 1968. The politics and economics of public spending. Brookings Institution. Washington, DC.

January 10, 1990.

EVALUATION OF FOREST RESOURCE PLANNING ACTIVITIES OF U. S. STATE GOVERNMENTS

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FDC: 903: 923.4: 945.1: 71: (73)

Comprehensive forest resource planning programs by U. S. state governments were prompted by the Cooperative Forestry Assistance Act of 1978 which gave states the opportunity to receive federal financial and technical planning assistance. The basic purposes of these state forest resource planning programs were to develop stronger and more efficient state forestry organizations and to ensure that information for nonfederal forest lands was effectively utilized in both federal and state natural resource planning programs. Since 1978, forty-eight states have undertaken such programs, at an annual expense of about $2 million [U.S. dollars], yet little is known about the effectiveness of these programs.

In 1986 a study of first-generation state forest resource planning programs was undertaken. Explored were questions such as: What benefits resulted from federal and state investments? How well were the planning programs carried out? And, what can be learned from these first-generation programs that could be used to improve future efforts?

The study adopted an approach known as "direct approach to strategic planning evaluation." This comprehensive approach advocates examining a broad range of potential planning benefits that might be expected to accrue from a variety of perspectives. The study identified numerous benefits and other measures of planning effectiveness within four major components of a strategic planning system: context, process, outputs, and performance. These measures were assessed through a mail survey of seven stakeholders (i.e., state forest resource planners, state foresters, administrative officials overseeing state forestry organizations, state budget directors, legislators, forest industry representatives, environmental group representatives) in 48 states, and through in-depth case studies in 5 states (i.e., New Hampshire, Mississippi, Minnesota, Oregon, California).

Assessments revealed great diversity among states; planning environments, processes used, and actual planning experiences varied significantly from state to state. In general, however, stakeholders perceived first-generation planning programs to have been quite effective -- they considered processes to be well-conceived, and they identified many broad benefits, as well as specific accomplishments, that accrued to state forestry organizations and state forestry communities as a result of planning.

The study identified successes and failures in planning and lead to recommendations for improving future planning programs. Also identified were needs for future research, such as the need for improved means of defining planning and for mechanisms by which individual state planning profiles can be created.

INTRODUCTION

In the United States, nearly 60 percent of the productive land area is owned by 8,000,000 private citizens for whom timber production as an ownership objective is far less important than consumption objectives such as outdoor recreation (Fesco, Kaiser, Royer and Weidenhamer 1982, Birch 1983). Yet, they annually market 48 percent of all timber sold in the United States (USDA 1988). Obviously, their continued marketing of these resources is critical to maintaining economic growth.

Central to the literature on non-industrial private forest (NIPF) owners has been the assumption that they need more and better quality market information (e.g., Rosen 1984). Yet we know virtually nothing about how much information NIPF owners collect, what their sources are, and importantly, how satisfied they are with the results of their efforts. Answering these questions is critical to improving public policy on this issue. Capon and Lutz (1979) suggest that government policy-makers tend to intervene based on the policy-makers' ideal information environment rather than the user's. Intervention should only follow a finding that consumers actually need more information.

Historically, the context for examining information needs of NIPF owners has been the limited literature on price reporting. While studies have focused on the extent of price reporting, sources of price information, and their veracity, no one has studied the degree to which NIPF owners actually use this information. This paper argues that NIPF owners can be best understood by viewing them as "consumer-marketers." That is, while the NIPF owner acquires and holds his forest land primarily for consumption objectives such as recreation and residency, at various points in time, he act as a non-professional seller and negotiator. As non-professionals, it is proposed that NIPF owners' search and decisions are most similar to their behavior as consumers rather than marketers. In contrast, NIPF owners sales are nearly always to professional buyers. The "consumer-marketer" is at a considerable informational disadvantage relative to the professional in several aspects including pricing, accurate assessment of the resource's condition, awareness of alternative marketing channels and an understanding of how these channels function. The inequities of information are particularly severe when the NIPF owner is an infrequent participant in the market, which is generally the case. The result can be a substantial welfare loss both to the NIPF owner (e.g., reduced returns, mismanaged harvest) and to society because of disaffected owners' reluctance to participate in the market.

Several questions are important in understanding NIPF owners' activities and performance. How do their ownership objectives affect information search and resulting decisions? What are their sources of information? Do they utilize professional information sources? To what extent are personal versus impersonal information sources used? How do their decisions compare with normative standards set by professionals? How does prior experience affect search?

This study explores the role of NIPF owners as "consumer-marketers" and presents the results of a field study of NIPF owners' search for information and their decisions in marketing their timber. This paper draws from the consumer behavior literature to provide a theoretical framework.

THEORETICAL BACKGROUND

Consumer search for information has traditionally been an issue of central concern to researchers in academia, government and business. For academics, search is a key variable in understanding how consumers assemble and integrate information in making decisions. For government and business, search is a point where policy makers and marketers can intervene to facilitate desirable outcomes. However, these objectives are frustrated by consumers' demonstrated reluctance to engage in extensive search. Beales, Mazis, Salop and Staelin (1981) note that consumers' lack of active search for information is often offered to explain the failure of government's attempts to impact consumer behavior. Before intervening, however, Capon and Lutz (1979) point out the need to determine if consumers genuinely require additional information. They suggest that policy-makers tend to implement action based on the policy-makers' ideal information environment, not the consumers.

One research objective has been to measure the extent of consumer information search. Several reviews of the literature (e.g., Beatty and Smith 1987, Newman 1977, Ratchford 1978) have concluded that consumers do not engage in extensive search. In laboratory studies, subjects typically collect only a small amount of the total information available (Ratchford 1978). For example, Jacoby, Fisher and Chestnut (1978) found that subjects collected only about 2% of all available information. Field studies have found similar results. Duncan and Olshavsky (1982) reported that 22 percent of their sample conducted no search whatsoever before purchasing a color television. Newman (1977), summarizing the findings of several studies, observed that typically, 40 to 60 percent of buyers visit only one store, regardless of whether the product is a durable or a nondurable.

Besides the amount of information collected, the source of that information has been studied. Beales et. al. (1981) identify three categories of information sources: direct inspection of the product, seller related sources and disinterested third parties. Capon and Lutz (1979) and Beatty and Smith (1987) distinguish information sources according to their motives in providing information. Their categories are commercial sources (e.g., manufacturer, retailer, trade association) with economic interests in the purchase, independent sources with no economic interest (e.g., rating groups, government agencies), and consumer-oriented, interpersonal sources with no economic interest such as friends.

Despite the availability of credible, neutral sources of information, available research suggests that consumers do not use them. Instead, they primarily rely on seller-related sources (Beales et al. 1981). For example, Beatty and Smith (1987) found that most search effort was spent on retailer visits followed by interpersonal sources then mass-media promotion and neutral sources. Beales et al. (1981) attribute the high reliance on seller related sources to the ubiquity of the information and it's availability without separate charges. In contrast, use of third-party sources such as rating services or consultants entails additional expense, effort and an unsure payoff.

Search Quality and Public Policy

Because of limited search by consumers and their heavy reliance on seller related sources, the quality of consumer's decisions has been questioned. While policy-makers are tempted to intervene with consumer-education programs to increase the extent and quality of search, researchers question the wisdom of such action. Ratchford (1980, 1982) suggests that the gains from increased search must be balanced against search costs and the risks resulting from a wrong guess. Where price and quality dispersion among sellers is large, gains from search are higher than when dispersion is small. However, based on Stigler's earlier suggestions, Urbany (1986) proposes that price dispersion is affected by buyer search, the rapidity of information obsolescence and the amount of advertising. Thus, high price dispersion can result where search is limited and buyers remain ignorant.

HYPOTHESES REGARDING SEARCH BY NIPF TIMBER MARKETERS

Based on the findings in the search literature, the average NIPF marketer of timber can be expected to engage in little search for information. This hypothesis rests on the assumption of symmetry. That is, NIPF owners will behave as marketers in a manner symmetric to their behavior as buyers.

By definition, NIPF owners may acquire and hold their property for reasons other than sale of timber. However, if they include timber production as an objective, the price received for timber can be presumed to be a key consideration in the sale. Despite the importance of price, because NIPF owners are relatively inactive in the marketplace, they are probably unaware of current price levels and are less skilled in search for price than the professional timber buyers they deal with.

NIPF owners may employ expert consultants to advise them on market operations or to completely manage the sale. Despite the objective value of outside expertise, prior findings that consumers rely largely on seller related sources when purchasing, suggest that NIPF owners will behave similarly when marketing.

That is, they will tend to rely on buyer-related information sources and will make little use of neutral or interpersonal sources.

Regarding search and decision quality, there will be a sharp difference between standards set by experts and the behavior of most NIPF marketers. Based on expert standards, NIPF owners will not engage in adequate search and their decisions be less than optimal.

AN INVESTIGATION OF SEARCH BY NIPF TIMBER MARKETERS

To test the propositions about the extent and quality of search by NIPF timber marketers, a field study was conducted. Based on Capon and Lutzs' (1979) and Jacoby's (1977) suggestions that judgments of extent and quality of search should consider both the consumer's and the professional's assessments, a three stage procedure was followed. First, extensive interviews were conducted with 26 forest products marketing experts from federal (U. S. Forest Service) and state agencies (New York Department of Environmental Conservation) as well as private industry, in order develop a normative model of search and decision regarding harvest and sale of timber. Second, to study non-industrial private forest (NIPF) owners' search and decisions, data was collected via a mail survey of NIPF owners. Third, the behavior of the NIPF owners was compared with the professional judgments. Also, the data were used to test the hypotheses suggested by the search literature in regard to the extent, sources and determinants of search.

Expert Judgments

When marketing timber, various types of information are needed including the alternative modes of pricing and harvesting, buyer availability and reliability, and importantly, information on market prices. Professionals recommend obtaining information from as many sources as possible. However, they note that because of the complex nature of timber harvesting, the information may be difficult for the consumer-marketers to interpret. Therefore, they suggest consulting third-parties, in this case professional foresters. Following Capon and Lutzs' (1979) categorization, sources of information include the following:

Commercial Sources: Competitive or single-source negotiated bids from buyers.

Independent Sources Government foresters; Private consultant foresters; State-issued semi-annual price reports compiled from information supplied by public and private foresters.

Consumer-Oriented Interpersonal Sources: Friends and neighbors with similar properties.

To summarize, the objective expert opinion is that in marketing their timber, NIPF marketers should have a professional forester mark and manage the sale and price information should be collected from a variety of sources and price should be set by competitive bidding rather than be set through negotiations with a single buyer. In addition, they recommend that the timber should be sold on a lump-sum rather than volume basis. The justification is that when volume based pricing is used in selective cuts, there is a very strong incentive for the buyer to "high-grade" the stand, particularly where supervision is weak.

Survey of NIPF Owners

Sample - Data on search and decisions in timber harvesting by consumer-marketers was collected via a survey of NIPF owners in New York State. New York is a good setting for the study because it has a high percentage of NIPF land, a greatly varied group of owners and an active forest products industry. The sample consisted of a census of all owners of more than ten acres of forested land in each of nine towns selected from across the state with the assistance of the New York State Department of Environmental Conservation, a total of 3,508 owners. The nine towns are comparable in resource and demographic characteristics.

Instrument and Procedure - The measurement instrument was a pretested mailed questionnaire. NIPF owners were surveyed on their experience and attitudes towards their properties and timber harvesting, their sources of price information, the price basis of their most recent timber sale, who marked and managed that harvest, the sale procedure, demographics, and topical opinion leadership using King and Summers' (1970) scale.

Response - Cumulative of the initial mailing and two follow-up mailings, a total of 2,304 usable questionnaires were returned, or 66 percent. 428 of the returned questionnaires were subsequently dropped from the study because the owners indicated that they did not have at least five acres of wooded land on their property, the minimum generally exploitable for timber.

To check for possible non-response bias, the respondent demographics, resource characteristics and percentage of owners with harvesting experience were compared to the findings of large-scale studies of NIPF owners in New York by Canham (1973) and Birch (1983). The comparison showed similar respondent profiles. That similarity plus the high response rate suggested a low probability of significant non-response bias.

RESULTS

To summarize the demographics of the sample, most of the properties are held by a group of owners who can be best characterized as middle age or older, with at least a high school education (27.8%) and probably a college education (22.2% have some college education, 36.3% are college graduates). They tend to have moderate incomes. Fifty one percent of the respondents have household incomes under $30,000 while 72 percent of respondents have household incomes under $45,000.

Eighty two percent of the respondents are sole proprietors of their properties while another 15 percent of the cases are family partnerships. The remaining three percent are primarily non-family partnerships. Eighty eight percent of respondents purchased the property, the rest usually inherited their land.

Most owners intend to keep their properties for some time to come. Sixty one percent will definitely not sell the land, and another 27 percent are unsure of their long term plans but will probably not sell within the next five years. Only 12 percent of owners definitely plan to sell within the next five years.

Most owners hold their property for a variety of purposes although residency (full or part-time) and recreation dominate in importance. Most respondents accept timber marketing as one component of their woodland management plans and few are strongly opposed to it.

Sources, Extent and Determinants of Information Collection

Of the 1,876 respondents retained for the analysis, 547 had marketed timber from their properties. The analysis of search and decision presented below is based on the responses of consumer-marketers who had already harvested timber at the time of the survey. As hypothesized, NIPF timber marketers engage in extremely limited search for information and the sources they consult are generally poor compared with the experts' recommendations. Table 1 contains data on the number and type of sources used by respondents to collect price data for their most recent harvest. The overwhelming majority (79%) of respondents consulted only one source for price data. For nearly half of the sample, that source was a single buyer of timber. About 26 percent of respondents checked prices with a number of buyers. Only about 16 percent consulted independent sources of market data such as private or government foresters and about 17 percent of respondents consulted consumer-oriented personal sources. Notably, only a minuscule number of respondents (22 or 4%) consulted the New York State Stumpage Price Report, which is the only printed independent source of price information.

NIPF Timber Marketers' Harvesting Decisions and Their Effects

As per Table 2, in contrast with expert recommendations, less than 25% of timber harvesters had utilized foresters, either public or private, in marketing their timber. Fifty three percent allowed the logger to conduct the selection and harvest of the timber to be removed, while approximately 23 percent managed the harvest themselves. Of the 25 percent of owners who used outside consultants, the use of private and public assistance was evenly split.

Table 1: Extent of NIPF timber marketers' use of various sources of timber price data

				Crosstabulation of sources to show pattern of multiple source use					
Source	N[a] Cases	% of Responses	% of Cases	Rec'd competitive bids from several buyers	Negotiations with a single buyer	Read state stumpage price report	Rec'd advice of a state, local, or consulting forester	Rec'd advice of friends and/or neighbors	Other
Commercial sources									
Received competitive bids from several buyers	142	21.3%	26.3%	—	NA[b]	10	20	15	3
Negotiations with a single buyer[b]	261	39.1%	48.4%		—	6	16	30	12
Independent sources									
Read the state stumpage price report	22	3.3%	4.1%			—	12	4	3
Rec'd advice of a state, local or consulting forester	85	12.7%	15.8%				—	9	3
Consumer-oriented interpersonal sources									
Rec'd advice of friends and/or neighbors	92	13.8%	17.1%					—	4
Other[c]	66	9.9%	12.2%						—

Use of multiple sources

Number of sources used	Number of cases[a]
One source	432
Two sources	86
Three sources	17
Four Sources	5

[a] Missing cases = 13

[b] The first two choices are mutually exclusive. Only in six cases did respondents check both responses. These cases were deleted from subsequent analyses.

[c] Respondents who checked "other" usually responded by indicating that they received advice from a mill or lumberyard owner.

As discussed earlier, the experts recommended selling timber on a lump-sum basis to prevent "high-grading." In contrast, the vast majority of owners sold on the basis of stumpage volume (X^2=30.41,p=.000). As per the table, this practice was the choice in 63% of cases where the logger managed the harvest, and in 81% of the cases where the owner managed the harvest. In contrast, where foresters managed the harvest, there was a preference for lump-sum sales.

How do these choices affect NIPF timber marketers' satisfaction? Table 3 shows how NIPF owners felt about the price they received for their timber and the post-harvest condition of their property under each of the four harvest-management regimes. On each of the three measures, owners who allowed the logger to manage the harvest scored the lowest of all the groups. Furthermore, for each of the measures, the mean values are below the neutral point. That is, those owners whose harvests were managed by the logger expressed dissatisfaction with the outcome relative to those who selected other approaches.

Table 2: Crosstabulation of price basis of most recent sale by choice of harvest manager

	Price basis of sale		
	Lump sum	Stumpage volume	
Harvest manager	(row pct)	(row pct)	Total (col pct)
The logger	106 (36.4%)	185 (63.6%)	291 (53.3%)
The NIPF owner himself	23 (18.7%)	100 (81.3%)	123 (22.5%)
A private consulting forester	35 (53.0%)	31 (47.0%)	66 (12.1%)
State or other government forester	36 (53.7%)	31 (46.3%)	67 (12.2%)
Total (row pct)	200 (36.6%)	347 (63.4%)	547 (100%)

$\chi^2 = 30.41, P < 0.000$

Table 3: Effects of NIPF timber marketers' choice of harvest manager [a] on satisfaction with most recent timber harvesting experience

Harvest manager	Price expected compared with price received[b]	Perceived fairness of price received[c]	Property condition after harvest[d]
The logger	3.62	3.46	3.83
The NIPF owner himself	4.88	4.11	4.42
A private consulting forester	4.22	4.88	4.12
State or other government forester	4.04	3.94	4.36
	$F = 3.63$, $P < 0.01$	$F = 6.12$, $P < 0.01$	$F = 3.82$, $P < 0.01$

[a] Values in each cell are means for respondents who chose each method of harvest management.

[b] 1 = Much lower than expected, 7 = much higher than expected.

[c] 1 = Less than fair price, 7 = more than fair price.

[d] 1 = Much worse than expected, 7 = much better than expected.

DISCUSSION

As hypothesized, when NIPF owners market their timber, their search activities are symmetric to their behavior as consumers. Both the extent of search and the quality of the sources consulted are low when compared with normative standards. NIPF timber marketers tend to consult very few sources, usually a single source, and those sources tend to be buyer-related. There is a little use of consumer-oriented interpersonal sources or independent sources.

This lack of information appears conducive to sub-optimal decisions. Although it could be argued that owners are simply acting in accordance with their utility function for information, that conclusion is contraindicated by the finding that those who made objectively sub-optimal decisions were significantly less satisfied with the outcome. Therefore their search and decisions fall short of satisfactory based on both objective criteria and the owners' own subjective criteria.

Should programs be implemented to educate and protect NIPF timber marketers? The results suggest that future NIPF educational efforts should focus on three objectives including: (1) making owners more aware of the returns to better search and decisions, (2) informing owners about the availability, role and value of alternative sources; and (3) teaching owners how to use that information.

REFERENCES

Beales. Howard, Michael B. Mazis, Steven C. Salop and Richard Staelin, 1981: Consumer Search and Public Policy. Journal of Consumer Research, 8, June, pp. 11-22.

Beatty, Sharon E. and Scott M. Smith, 1987: External Search Effort: An Investigation Across Several Product Categories. Journal of Consumer Research, 14, June, pp. 83-95.

Birch, Thomas W., 1983: Private Forestland Owners in the United States: Their Number and Characteristics. in Nonindustrial Private Forests: A Review of Economic and Policy Studies, eds. Jack Royer and Christopher Risbrudt, Durham, NC: Duke University.

Canham, Hugh O., 1973: Forest Ownership and Timber Supply, Syracuse, NY: State University of New York College of Environmental Science and Forestry.

Capon. Noel and Richard J. Lutz, 1979: A Model and Methodology For The Development of Consumer Information Programs. Journal of Marketing, 43, January, pp. 58-67.

Duncan, Calvin P. and Richard W. Olshavsky, 1982: External Search: The Role of Consumer Beliefs. Journal of Marketing Research, 19, February, pp. 32-43.

Fesco, R. S., Kaiser, H. Fred, Royer, Jack, and M. Weidenhamer, 1982: Management Practices and Reforestation Decisions for Harvesting Timber, AGES 821230. Washington, D.C.: Statistical Reporting Service.

Henion II, Karl E., 1981: Energy Usage and the Conserver Society: Review of the 1979 AMA Conference on Ecological Marketing. Journal of Consumer Research, 8, December, pp. 339-342.

Jacoby, Jacob, 1977: Information Load and Decision Quality: Some Contested Issues. Journal of Marketing Research, 14, November, pp. 569-73.

Jacoby, Jacob, Robert W. Chestnut and William A. Fisher, 1978: A Behavioral Process Approach to Information Acquisition in Nondurable Purchasing. Journal of Marketing Research, 15, November, pp. 532-44.

Katona, George and E. Meuller, 1955: A Study of Purchasing Decisions. in Consumer Behavior: The Dynamics of Consumer Reaction, ed. Lincoln H. Clark, New York: New York University Press, pp. 30-87.

Keil, Geoffrey C. and Roger A. Layton, 1981: Dimensions of Consumer Information Seeking Behavior. Journal of Marketing Research, 18, May, pp. 233-239.

King, Charles W. and John O. Summers,, 1970: Overlap of Opinion Leadership Across Consumer Product Categories. *Journal of Marketing Research*, 7, February, pp. 43-50.

Kurtz, William B. and Bernard J. Lewis, 1981: Decision-Making Framework For Nonindustrial Private Forest Owners: An Application to the Missouri Ozarks. *Journal of Forestry*, 79, May, pp. 285-288.

Mcneill, Dennis L. and William L. Wilkie, 1979: Public Policy and Consumer Information: Impact of the New Energy Labels. *Journal of Consumer Research*, 6, June, pp. 1-11.

Newman, Joseph W., 1977: Consumer External Search: Amount and Determinants. in *Consumer and Industrial Buying Behavior*, eds. Arch Woodside, Jagdish Seth, and Peter Bennett, New York: North-Holland.

Ratchford, Brian T., 1978: Consumer Choice Behavior Review and Synthesis. Buffalo, NY: State University of New York, Working Paper No. 78-9.

Ratchford, Brian T., 1980: The Value of Information for Selected Appliances. *Journal of Marketing Research*, 17, February, pp. 14-25.

Ratchford, Brian T., 1982: Cost-Benefit Models For Explaining Consumer Choice and Information Seeking Behavior. *Management Science*, 28, February, pp. 197-212.

Urbany, Joel, E., 1986: An Experimental Examination of the Economics of Information. *Journal of Consumer Research*, 13, September, pp. 257-271.

USDA/Forest Service, 1988, *An Analysis of the Timber Situation in the United States: 1989-2040*, Washington, D.C.: USDA/Forest Service.

LES ENJEUX FORESTIERS DES LEGISLATIONS FONCIERES EN AFRIQUE SECHE

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RESUME

Le statut foncier et les réglementations correspondantes tiennent en matière de gestion forestière une place importante. Dans les pays en développement, où la forêt existe d'abord comme espace utilisé pour l'agriculture, les conditions de définition juridique de l'appropriation et de la gestion des terres conditionnent en effet directement les niveaux d'efficacité des législations forestières. Ceci est particulièrement le cas dans les zones arides et semi-arides, où l'intensification de l'agriculture ne peut être que limitée. Dans ces régions, la redéfinition de statuts fonciers adaptés doit être considérée comme une mesure indispensable, voire même préalable, à l'organisation d'une législation forestière. Quelques alternatives actuelles en Afrique sèche sont, dans cette optique, présentées et comparées.

mots-clés : législation forestière, propriété forestière, politique forestière, Afrique.

SUMMARY

The land tenure status and the related regulations take a large place regarding forest management. In developing countries, where forest means first forest land used for agricultural activities, the way the property and management of land are defined by the law generally makes the forest policy measures more or less effective. This is particularly the case for arid and semi-arid areas, where intensifying agriculture is difficult. There, modifying the land tenure status must be considered as a necessary and sometimes preliminary mean to organize a forestry legislation. Some present alternatives in dry Africa are described from this point of view, and compared together.

keywords : forest legislation, forest ownership, forest policy, Africa.

INTRODUCTION

Depuis une vingtaine d'années, beaucoup de pays en développement ont réorienté leurs législations forestières dans le sens d'une meilleure prise en compte des besoins locaux. C'est que la crise forestière à laquelle certains d'entre eux devaient faire face ne pouvait être résolue sans une participation plus complète de l'ensemble des intéressés, les états étant mal armés pour faire face seuls à la situation. Ceci n'était donc guère possible à partir de l'appareil réglementaire traditionnel, lequel s'attachait surtout à exclure les usagers. En accompagnement des nouvelles mesures techniques préconisées à cet effet, les règles d'encadrement de la gestion forestière ont donc été modifiées pour favoriser cette participation (SCHMITHÜSEN, 1981 ; BERTRAND, 1985).

Cette évolution s'est trouvée entravée par un ensemble de facteurs.

D'abord, il s'est avéré que les différentes forces sociales en présence (paysans, forestiers, notables ruraux) avaient toutes intérêt au maintien de l'équilibre antérieur, lequel garantissait au moins à court terme leur complète liberté d'action, puisque la réglementation correspondante n'était de fait pas appliquée (BUTTOUD, 1986 et 1989a).

Ensuite, beaucoup d'opérations de production forestière préconisées dans le nouveau système n'ont pu être menées à terme en raison de contradictions profondes avec le statut foncier, tant il est vrai que les modes de gestion dérivent de façon directe des formes d'appropriation du facteur de production central qu'est la terre. Vouloir responsabiliser les paysans en les faisant participer au reboisement et à l'entretien des ressources boisées n'a en particulier guère de sens si ceux-ci ne sont pas assurés de pouvoir bénéficier des produits qui seront tirés plus tard de ces opérations ; or cette garantie réside essentiellement dans le statut d'appropriation de la terre. La nécessité d'assurer aux paysans un minimum de sécurité foncière constitue à n'en point douter l'élément central d'une politique de responsabilisation des populations à l'entretien des ressources naturelles. Dans l'efficacité des législations forestières favorisant la participation locale, la question foncière joue ainsi un rôle central (SCHMITHÜSEN, 1986 ; BUTTOUD, 1989b).

FORET, OU ESPACE BOISE ?

Il faut bien voir en effet que, dans les pays en développement, la forêt est d'abord un espace considéré comme résiduel, et où se superposent plusieurs types d'utilisations rurales. C'est là qu'on va chercher l'énergie nécessaire au chauffage et surtout à la cuisson des aliments, qu'on promène son bétail qui ne peut trouver ailleurs les conditions de sa survie en saison sèche, qu'on se procure par la chasse un appoint en protéines. Et c'est là surtout qu'on va implanter de nouvelles cultures lorsque le besoin s'en fait ressentir.

S'il fallait donc mesurer la valeur de la production effective tirée des forêts, notamment dans les zones arides et semi-arides, il est clair que les produits ligneux n'en constitueraient d'abord qu'une partie minime. Mais il est également tout aussi clair que la valeur potentielle -monétaire ou non- implicitement attribuée par les paysans à ces forêts résiderait essentiellement, et parfois même exclusivement, dans cette fonction de réserve foncière qu'elles assurent au service de la reproduction à l'identique de l'ensemble du système productif local.

Ainsi, avant d'être un outil de fabrication de produits ligneux, ces forêts là sont d'abord un espace, un lieu où l'on vient chercher de la place disponible pour accroitre la production agro-pastorale. Ce sont d'abord ce qu'on peut appeler des "espaces boisés", lesquels constituent une ressource rurale, même définie d'une certaine façon par la négative, dans la mesure où ils se résument largement à un ensemble de terres plus ou moins disponibles.

Cette considération a des implications importantes en matière de réglementation des pratiques induites. Pour participer de façon plus directe et intense au développement, l'utilisation de cet espace par la société locale ou globale doit en effet être régulée de telle sorte que 2 conditions soient remplies :

- La première est que la réglementation forestière soit un sous-ensemble de la législation plus globale régissant les rapports au milieu rural ; car quelle pourrait être le caractère opérationnel de lois forestières qui viendraient contredire le code rural en vigueur, lequel a pour fonction d'encadrer des pratiques sociales qui ont, elles, des incidences directes sur l'utilisation des forêts?

- La seconde de ces conditions est que la législation foncière, celle qui régit l'accès à la terre, soit le plus possible adaptée aux objectifs poursuivis en matière d'entretien des ressources naturelles. Dans la mesure où, actuellement, le régime foncier est source d'insécurité pour les paysans, c'est en effet la question de la maitrise à long terme de l'usage des terres qui peut peser le plus directement sur l'efficacité des efforts de conscientisation des populations à l'obligation dans laquelle elles se trouvent d'entretenir leur environnement naturel. A cet égard, le statut d'appropriation et de gestion des terres apparait ainsi comme un déterminant direct de l'efficacité des mesures techniques et économiques qui pourraient être prises en faveur du développement forestier.

Or le gros problème réside justement dans le fait que ce statut foncier n'est que rarement adapté. Généralement d'ailleurs, et du fait justement de cette inadaptabilité aux pratiques concrètes, il reste tout simplement inappliqué, ce qui contribue à entretenir un flou dont on voit bien que les différents acteurs en présence se servent pour légitimer a posteriori tous types de pratiques. La question qui se pose un peu partout n'est donc pas, comme on le dit le plus souvent, de changer ce statut foncier, mais bien déjà de le définir, ce qui n'est pas forcément plus facile à faire qu'à dire.

L'exemple de l'Afrique sèche est à cet égard des plus significatifs.

LE STATUT DOMANIAL DES TERRES EN QUESTION

Quand le droit moderne est arrivé en Afrique sub-saharienne avec la colonisation française, la question foncière a été réglée par une formule simple : les terres sans maître (implicitement privé) reviendraient à l'Etat. Les espaces naturels, qui n'appartenaient généralement à aucune entité juridiquement définie, se sont ainsi trouvés ipso facto nationalisés.

Les modes traditionnels d'utilisation par les paysans des espaces boisés, régis par la coutume, laquelle constitue l'élément dynamique majeur des systèmes fonciers, se sont-ils retrouvés pour autant illégaux? Certes non, mais reléguées au rang de simples droits d'usage provisoires, les pratiques coutumières n'ont été reconnues qu'à titre précaire. Et si les populations rurales peuvent encore, sous certaines conditions, satisfaire à leurs besoins vitaux, elles restent encadrées par un droit écrit qui est en contradiction complète avec la réglementation traditionnelle, et qui vise de ce fait à son extinction concrète. En principe du moins, c'est ce droit qui prime systématiquement sur les règles orales en cas de conflit.

Sans doute le droit formel ne prend-il souvent, dans l'orientation des pratiques forestières, qu'un rôle indirect qui peut paraître de ce fait limité. Au Mali par exemple, comme dans d'autres pays de la zone sahélienne, il n'est brandi par l'administration vis à vis des paysans qu'à titre de menace ultime, pour susciter des ententes amiables locales qui, elles, puisent le plus souvent dans la tradition coutumière. Mais si ce type d'usage administratif du droit traduit bien ses difficultés d'application concrète, il n'empêche que c'est sur de telles bases que repose actuellement tout dispositif réglementaire qui serait conçu pour susciter une politique globale de développement des ressources naturelles de la zone. Et un tel droit, issu du statut privé de la propriété domaniale, ne peut que décourager les initiatives participatives.

En fait, les législations foncières modernes, qui depuis l'époque coloniale ont substitué à une superposition des usages une juxtaposition des propriétés, s'attachent à promouvoir implicitement un mode de développement rural fondé sur la mise en valeur économique des terres, qu'un système extensif hérité de l'histoire ne leur semble pas devoir assurer. Sous des formes diverses, cette négation de l'utilité sociale de la coutume forestière, que la législation a fini par institutionnaliser, rend désormais très difficile pour ne pas dire illusoire toute tentative organisée de susciter un nouveau dynamisme collectif dans la maîtrise des espaces boisés. La forêt, où l'Etat s'est en principe attribué une sorte de droit d'usage exclusif, tend ainsi à être perçue comme un ensemble d'interdits.

Avec le temps, la primauté du droit de propriété sur les règles d'usage s'est alors accentuée, même après les indépendances. Dans certains pays comme le Mali, la présomption d'appartenance exclusive au domaine privé de l'Etat a été appliquée aux terrains dont les usagers n'étaient pas en mesure de fournir la preuve matérielle de leurs droits. Même là où elle a été instituée pour favoriser les pratiques collectives, comme au Sénégal et au Burkina, l'attribution des terres au peuple par nationalisation ne paraît pas avoir eu en matière forestière d'incidence positive, faute de s'être accompagnée d'une mutation des procédures d'encadrement administratif. Dans certains cas, la rétrocession par concession de terres à des paysans plus dynamiques a même précarisé la situation des sans-terres.

Confrontés à cet environnement juridique, les paysans africains ont réagi par des stratégies relevant de leur logique propre, par exemple en tentant de contrôler concrètement l'espace foncier par des méthodes culturales extensives, ou encore en cherchant non pas à accroître la rentabilité du sol, mais la productivité du travail. La superposition des usages s'est trouvée alors gérée par une superposition des droits correspondants, ce qui a eu pour effet d'accentuer encore la dégradation des ressources naturelles. Le droit forestier domanial, tel qu'actuellement défini, ne constitue donc pas un outil adapté à la protection des espaces boisés africains.

LES LIMITES DE L'APPROPRIATION PRIVEE DES ESPACES BOISES

La solution la plus généralement préconisée pour remédier à cette situation consiste à promouvoir, en réaction, une propriété forestière privée. Une réallocation juridique des terres pourrait dans ce cas s'effectuer par allotissement privé de terrains réputés jusqu'alors collectifs.

La préoccupation centrale est ici de garantir le droit exclusif de ceux qui investissent en travail dans l'amélioration de la jachère de récolter les produits obtenus sans partage avec d'autres (comme les éleveurs itinérants par exemple). La garantie de cette exclusivité, qui provient dès lors d'un titre de propriété, fournirait les conditions d'une efficacité de la vulgarisation forestière. Dès l'instant qu'un acte juridique formel de cette nature établit clairement que le bénéficiaire des produits de la terre est exclusivement celui qui conduit sa mise en valeur, on peut penser que la plantation et l'entretien d'arbres seraient menés dans le souci d'assurer à long terme un approvisionnement régulier.

Des exemples locaux existent de réussite de la formule. Dans la périphérie de certaines villes du Sahel, comme par exemple à Kano, au Nigeria, cette privatisation -généralement spontanée- a pu aboutir à des résultats positifs : malgré la densité plus importante de la population, les arbres ont en effet été maintenus grâce à des pratiques agroforestières suscitées par l'intérêt privé ; ils ont été en tout cas plus facilement protégés que dans les zones rurales plus éloignées, où le régime de propriété publique entraîne des exploitations abusives et où la généralisation du transport du combustible ligneux par gros camions concentre les chantiers, attirés par des prix d'acquisition dérisoires.

Sans doute le risque d'une telle privatisation est-il grand que le système soit mis à profit par des spéculateurs pour accaparer des terres avec la caution de la loi, qui serait alors déviée de son objectif. Le risque existe aussi que les autorités publiques utilisent ce type d'action foncière pour favoriser certains groupes, ou au contraire pour encadrer, par un contrôle plus étroit des paysans ainsi sédentarisés, des intérêts tribaux qu'elles souhaiteraient subordonner aux demandes de groupes urbains. Là où les éleveurs disposent de fait de droits d'usage, les conflits qui risquent de surgir peuvent s'avérer difficilement contrôlables.

De toute façon, la propriété forestière privée, lorsqu'elle résulte d'une monétarisation de l'économie dûe à l'attraction urbaine, ne garantit pas en elle-même la perennisation des ressources boisées. La gestion par les particuliers des taillis d'eucalyptus des plateaux centraux de Madagascar se borne par exemple à profiter d'une valeur marchande qui résulte trop de la pénurie pour tenir compte des coûts d'entretien et de renouvellement. S'agissant de ressources naturelles, le marché ne régule pas plus que ne le fait l'Etat.

Mais le principal défaut de la formule est à rechercher dans le fait que l'appropriation privée est complètement inadaptée à la conception que les Africains se font de leur rapport à la terre.

D'abord parce qu'en zone aride, les systèmes productifs sont nécessairement mobiles, et s'exercent sur un espace mal défini puisque fluctuant au gré de la pluviométrie. Les principaux objectifs concrets de la gestion paysanne sont alors de contrôler les points d'eau d'une part, et de s'assurer du renouvellement de la fertilité des sols d'autre part. Or l'appropriation privative de l'espace, qui lie l'individu à un espace géographiquement circonscrit, ne peut ni réguler l'accès aux puits, ni garantir le respect des droits sur les jachères. Elle n'apparait donc pas vraiment indispensable. Le plus important est sans doute de se doter d'une structuration villageoise qui permette la prise de décision à l'intérieur du groupe des paysans locaux.

Ensuite, et surtout, parce que le droit moderne fait de la terre une chose, un objet d'appropriation par l'homme. Or pour les sociétés traditionnelles africaines, le sol est d'abord un lieu de la communauté, un espace qui est partie constitutive de la société et de l'identité culturelle. De ce point de vue, ce n'est donc pas l'homme qui possède la terre, mais la terre qui possède l'homme. De plus, l'individu n'existe pas dans sa singularité propre et abstraite, mais dans sa participation au groupe. Dans les sociétés traditionnelles africaines, le droit n'est en effet pas constitué en domaine propre, lequel aurait un système autonome de règles et un champ d'application spécifique. Il se définit au contraire en référence à l'ensemble du système de valeurs et d'idées, qui, lui, forme un tout. La terre elle-même participe ainsi au système des relations sociales. En privatisant les rapports entre particuliers, le droit moderne tend donc à ignorer les liens de dépendance hiérarchique et de solidarité communautaire, et du coup rompt la relation existant entre le statut du sol et celui des membres du groupe. La terminologie juridique et la classification modernes s'avèrent de la sorte inadaptées à saisir les rapports qui, dans les civilisations traditionnelles d'Afrique sèche, lient les hommes à la terre.

La perception traditionnelle de ce qu'est la terre fait perdre ainsi à l'acheteur éventuel sa qualité reconnue de membre du groupe. Du coup, entre d'une part une garantie juridique offerte par le titre foncier et qui vaut inscription dans la société moderne, et d'autre part une garantie sociale basée sur la participation solidaire à la communauté locale, il est rare que les villageois penchent pour la première. Il n'est que de constater combien l'extension de la propriété privée dans certaines zones, notamment péri-urbaines, de l'Afrique sèche s'est effectuée dans l'anarchie et parfois l'illégalité, et qu'elle a généralement été le fait d'acquéreurs extérieurs à la société locale (commerçants, fonctionnaires), parfois soutenus contre elle par l'autorité centrale. Ainsi, quand cette propriété privée apparait, elle est rarement le reflet d'une modernité juridique, mais bien au contraire une forme d'irrégularité, voire même d'illégitimité. De toute façon, il s'agit là d'une sorte de réinvention du privé résultant de la transposition d'un modèle dans un contexte qui ne s'y prête qu'imparfaitement.

Ces contraintes à la privatisation foncière sont d'ailleurs bien connues des gouvernements africains, qui cherchent parfois à en limiter les effets en n'établissant qu'une concession simple, et non une propriété pleine, et en prévoyant même que celle-ci n'entraine aucune modification du statut du sol et qu'elle cesse de plein droit dès lors que la forêt ne serait plus entretenue. Ces concessions ne sont accordées en principe qu'à ceux qui peuvent justifier de droits exclusifs sur la terre, ou bien sont conclues sous réserve des droits des tiers, ce qui limite de ce fait beaucoup leur capacité à susciter les initiatives indviduelles en faveur du boisement.

En fait, on constate qu'aucun des deux grands systèmes d'appropriation foncière en vigueur aujourd'hui en Afrique sèche (l'Etat d'un côté, le privé de l'autre) n'est susceptible de permettre un développement endogène et autocentré qui puisse disposer d'une stabilité suffisante et qui soit fondé sur la responsabilisation des paysans à l'entretien du milieu.

L'INTERET D'UNE COMMUNALISATION DE LA GESTION DES RESSOURCES NATURELLES

Dès lors, l'alternative consiste à rechercher une adaptation de l'ensemble des pratiques communautaires au droit moderne, en favorisant des réformes reposant sur les représentations indigènes des modes de sécurisation des droits fonciers. L'enjeu fondamental pour susciter une action collective d'envergure en faveur de la défense des milieux naturels forestiers peut consister alors à transformer des usages communautaires en propriété communale. Car en donnant au groupe social local un statut juridique moderne garantissant son autonomie, on crée alors les conditions d'une plus grande convergence entre les pratiques communautaires qui sont traditionnellement conduites, et les actions techniques à entreprendre pour sauvegarder un patrimoine forestier qui doit être perçu comme collectif.

La communalisation de la gestion forestière n'implique pas forcément une appropriation foncière de la part de collectivités locales ainsi identifiées et juridiquement définies. L'Etat peut fort bien rester le propriétaire du sol, mais sûrement pas en tant qu'entité particulière, comme c'est le cas actuellement dans les anciennes colonies françaises. Dans une telle perspective, le concept de domaine privé de l'Etat doit être changé au profit de celui de patrimoine collectif national, ce qui a bien-sûr des implications juridiques importantes.

Sans doute une telle évolution législative, qui s'avérerait d'autant plus efficace que les intérêts fonciers locaux sont homogènes, n'est possible que si les objectifs, définis au niveau villageois et soumis bien-sûr à un débat suffisamment collectif et transparent, se trouvent légitimés et respectés par les intervenants techniques que sont les forestiers. Dans ce cadre, on pourrait par exemple concevoir que les villages puissent être considérés eux-mêmes comme exploitants, et devenir ainsi les uniques bénéficiaires de l'attribution des permis de coupe. Ils pourraient de la sorte s'assurer de la maîtrise des récoltes, et vendre les produits façonnés et les arbres sur pied à des commerçants extérieurs. Consacrer ainsi les droits des paysans sur les espaces boisés aurait donc de profondes implications réglementaires.

Quelques exemples, à vrai dire fort rares en Afrique, attestent de l'efficacité de cette orientation juridique dans la promotion du développement forestier.

Le cas du Rwanda, d'abord, montre combien l'organisation locale en communes dotées de la personnalité juridique et de l'autonomie financière a permis de donner à l'effort national de reboisement une ampleur qui n'a pas d'égal en Afrique. L'entretien par les communes seules de territoires qui restent dans le domaine national mais qui leur sont exclusivement attribués, s'effectue ici grâce à une organisation très poussée de la vie locale (pépinières communales, plantations collectives auxquelles les paysans consacrent une demi-journée par semaine) sur laquelle l'administration forestière elle-même n'intervient que comme simple prestataire de services. L'Etat rwandais n'encadre qu'au travers du discours idéologique national et des fournitures (conseils techniques, mise à disposition d'intrants) qu'il apporte. Et dans la conduite de ces actions, les bourgmestres disposent d'une grande latitude, qu'ils tirent d'une autorité supérieure aux agents forestiers. Mieux qu'au niveau national, la conscientisation collective fonctionne, et la mobilisation des énergies locales est alors possible. C'est, entre autres, grâce à cette gestion foncière communale et à son effet d'entraînement que les collines rwandaises ont en grande partie reverdi depuis une quinzaine d'années.

Le Mali fournit un autre exemple, différent, de l'intérêt qu'il peut y avoir à donner au local une identité juridique. Dans ce pays, une évolution dans le sens d'une communalisation est en cours de formulation. Des massifs forestiers, dont les paysans assumeraient collectivement l'entretien et la gestion, seraient attribués par contrats à des villages qui en auraient l'usage exclusif, dans le cadre d'un nouveau code domanial portant réforme agraire. Des plans d'aménagement collectif à long terme, le cas échéant avec zonage et affectations diverses dont certaines à usages multiples et d'autres pas, mais toujours sous responsabilité collective, seraient alors définis avec l'appui et sous le contrôle des services forestiers. La propriété de la terre, comme au Rwanda, resterait du domaine de la collectivité nationale, mais son utilisation dépendrait des décisions prises au niveau communal.

On voit bien, à l'énoncé de ces deux exemples qui ne sont certes pas transposables en l'état, que le problème foncier ne se limite pas aux seules modalités d'appropriation des terres. Dans ce domaine, la propriété elle-même compte peut-être moins que son mode d'utilisation. On peut constater aussi que les contraintes à une meilleure efficacité législative sont souvent nées du processus historique de constitution de l'Etat et de ses modalités d'intervention dans l'encadrement de l'utilisation des espaces naturels. C'est parfois parce que l'appropriation des terres ne fait pas l'objet de règles strictes qu'il est alors possible d'établir un statut foncier à la fois adapté aux objectifs de conservation forestière et respectueux de certaines pratiques locales. C'est parfois aussi parce que l'appareil administratif est resté longtemps quasi inexistant qu'on peut définir des règles d'encadrement garantissant le renouvellement de la ressource forestière par une responsabilisation locale.

L'incertain juridique sur le statut des espaces naturels ne s'opposerait alors qu'apparemment à la définition de ces nouvelles règles communes de gestion des ressources.

CONCLUSION

Les conditions actuelles d'accès à la terre en Afrique sèche résultent d'un système de production qui a été établi, dans ses rapports à l'écologie, dans une situation générale où le travail était un facteur de production plus rare que le sol. Aujourd'hui, c'est l'inverse qui se passe. Il faut donc redéfinir les droits fonciers, et pour qu'une telle réforme soit efficace, il apparaît nécessaire de remplacer la dualité actuelle des cadres juridiques traditionnel et moderne en réalisant leur intégration en un droit unique à préciser.

Même si les difficultés rencontrées pour promouvoir ce type de changement sont nombreuses, il se pourrait bien que l'adoption en Afrique sèche de législations forestières susceptibles d'enrayer la dégradation des espaces boisés doive passer par la redéfinition juridique d'un collectif local, la commune, qui seule peut faire la synthèse des divers intérêts locaux en présence, l'Etat -et donc l'administration forestière- n'intervenant dès lors que comme conseiller technique des actions entreprises.

Mais quelles que puissent être les solutions retenues pour y arriver, de la façon avec laquelle la question foncière -qui n'est pas seulement un enjeu législatif mais aussi et surtout politique- sera traitée, dépend au moins en partie l'avenir des espaces naturels de l'Afrique sèche.

BIBLIOGRAPHIE

- BERTRAND, A., 1985: Les nouvelles politiques de foresterie en milieu rural : réglementations foncières et forestières, et gestion des ressources ligneuses naturelles dans les pays de la zone soudano-sahélienne, Bois et Forêts des Tropiques, n° 207, pp. 23-39.

- BUTTOUD, G., 1986: Législation forestière et crise agraire : le cas des pays d'Afrique périsaharienne, in : Schmithüsen, F. (Edit.), Forstgesetzgebung, ETH Zurich, pp. 38-48.

- BUTTOUD, G., 1989a: Politiques et pratiques forestières en Afrique sèche, Economie Rurale, n° 191, pp. 3-7.

- BUTTOUD, G., 1989b: Les produits forestiers dans l'économie africaine, ACCT-CILF-Presses Universitaires de France, Paris, 321 p.

- FORTMANN, L., 1984: The tree tenure factor in agroforestry with particular reference to Africa, Agroforestry Systems, vol. 2, pp. 231-248.

- LE BRIS, E. et al. (Edit.), 1982: Enjeux fonciers en Afrique noire, Karthala, Paris, 426 p.

- LE ROY, E., 1987: La réforme du droit de la terre dans certains pays d'Afrique francophone, FAO, Rome, 109 p.

- MOORE, G., 1986: The impact of non-forestry laws on forestry, in : Schmithüsen, F. (Edit.), Forstgesetzgebung, ETH Zurich, pp. 88-101.

- SCHMITHÜSEN, F., 1981: Recent trends of legislation in developing countries, XVIIth IUFRO World Congress proceedings, Kyoto, div. 4, pp. 317-328.

- SCHMITHÜSEN, F., 1986: The impact of land-tenure on rural forestry development, in : Schmithüsen, F. (Edit.), Forstgesetzgebung, ETH Zurich, pp. 121-140.

- VERDIER, R. et ROCHEGUDE, A., Edit., 1986: Systèmes fonciers à la ville et au village : Afrique noire francophone, L'Harmattan, Paris, 298 p.

28 novembre 1989

RESULTS OF EXPERIMENTAL THINNING SERIES IN YOUNG DOUGLAS FIR PLANTATIONS

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FDC: 242: 181.65: 174.7 Pseudotsuga menziesii Franco

SUMMARY

Among all foreign tree species introduced into Italy for forestry purposes, Douglas fir came up best to foresters'expectation. In this context, the present paper shows the results of a large experimental program on different thinning types in young Douglas fir plantations. Technical and economic considerations about the thinning types are reported. Superiority of selective thinning types is confirmed, as far as growing conditions and volume yields are concerned.

Keywords: Thinning trials, young plantations, Douglas fir

INTRODUCTION

A major experimental program on the introduction of foreign tree species has been undertaken in Italy in 1922, taking into account all main environmental conditions of our country. Douglas fir (*Pseudotsuga menziesii* Mirb. (Franco)) production and diffusion potentialities became quite evident soon and have been documented in the report produced after twenty years of research (Pavari and De Philippis 1941).

First yield studies (Cantiani 1965) confirmed initial appraisals estimating total volume yields between 478 and 922 m^3/ha at 40 years; mean annual increments were estimated to be at maximum level for best sites with 20 to 23 $m^3ha^{-1}yr^{-1}$ at ages between 40 and 45 years. On worst sites, at same age the mean annual increment was estimated to be in the range from 12 to 15 $m^3ha^{-1}yr^{-1}$ and still increasing.

Carrying on the research program started in 1922, Ciancio et al. (1983) observed quite frequently stands with more than 1000 m^3/ha of standing volume at 50 years and a total volume mean increment of 24–25 $m^3ha^{-1}yr^{-1}$.

Yields of Douglas fir plantations in Italy appear to be greater than those reported for England (Rollison 1985), Germany

(Wiedemann and Schober 1957), France (Pardé 1956) and for natural stands of the north-western pacific coast (Mc Ardle, Meyer and Bruce 1961). It is interesting to point out that most productive Italian plantations originate from Oregon and Washington seed provenances.

Given results reported in the literature and our own experience, we fully agree with the statement of Ciancio et al. (1983): "among all foreign tree species introduced into Italy for forestry purposes, Douglas fir came up best to foresters'expectation".

This species plays a major role in Italian sylviculture also because, within its optimal vegetation zone, no indigenous conifer has similar characteristics (productivity, etc.). Furthemore, after 50 year of cultivation, no relevant disease has been observed in Douglas fir stands.

Plantations of this species are present in almost all Italian regions: Tuscany shows greatest diffusion with 3-4000 ha (Bernetti 1987).

First plantations have been executed with localized site cultivation or, for plantations on old-fields, complete cultivation. In coppice substitution, stools were first removed, since otherwise the need for frequent clearing of coppice shoots caused problems. High plantation densities of over 3000 trees/ha, characteristic of *Abies alba* (Mill.) plantations, were first adopted, but caused problems due to high costs and to the need of many precommercial thinning. Planting densities have since been reduced to 2500-1600 trees/ha (spacings of 2*2, 2*2.5 and 2.5*2.5 meters). At present, lower densities are being evaluated in the attempt to further reduce planting costs, to skip precommercial thinning and to delay first commercial thinning.

Notwithstanding the experimental results already achieved, not all problems concerning Douglas fir sylviculture are fully settled yet, due also to its relatively recent introduction. Nonetheless, disregarding short rotation plantations not adopted in our country, there is a general agreement for frequent and fundamentally heavy thinning aiming at saw logs production.

The present work reports results of a large experimental program on different thinning types in young Douglas fir plantations.

MATERIALS AND METHODS

Experimental Plantations

The program considered 5 young plantations located on different sites of central Italy:

A - "Foreste Casentinesi", Tuscany
B - "Acquapartita", Emilia Romagna
C - "Basso Mugello", Tuscany

D - "Poggio Nibbio", Latium
E - "Rufina", Tuscany

The plantations are located at elevations between 750 and 900 m a.s.l., on soils predominantly siliceous, loose and fundamentally acid. Climate is humid Mediterranean: mean annual temperature between 11 and 15°C, mean annual rainfall range 1000-1400 mm, summer aridity period less than one month, frequent winter snowfalls.

Thinning Criteria

No prior experience was available for objective determination of best age for first thinning, therefore several factors have been considered collectively:

- social differentiation within the stand (generally stands were thinned when the coefficient of variation of the dbh distribution exceeded 20%);
- plantation height development relative to its density (thinning generally when dominant height was not more than 6-7 times average inter-tree distance);
- stand stability towards meteorological damages (considering that damage probability greatly increases for values of height to dbh ratio greater than 80-90).

Considering planting density and tree development, thinning weights have been determined seeking comparable interventions in all different conditions:

- with planting densities near to 1000 trees/ha, since height to dbh ratios are generally low, crowns were entirely released by thinning;
- at higher densities (2000-2500 trees/ha), since wind- and snow- damage risks are higher, a certain degree of crown contact has been preserved.

In terms of number of trees, 30% (20 to 40%) of present stand has been removed by thinning at plantation ages between 16 and 20 years.

Thinning types have been tested applying the following treatments:

N - no thinning (control);
L - selective low thinning (trees are removed predominantly from lower canopy: suppressed, sub-dominant and selected co-dominant trees);
C - selective crown thinning (trees are removed predominantly from upper canopy giving selected dominants freedom to grow rapidly);
R1/4 - combined thinning: systematic removal of one row out of 4 followed by low thinning;
R1/6 - combined thinning: systematic removal of one row out of 6 followed by low thinning.

Not all treatments have been tested on all sites. Within each plantation treatments have been assigned to parcels according to complete randomized block design considering (almost always) 3 repetitions.

The main experimental data are summarized in tables 1 and 2.

RESULTS

Growth responses

In the considered plantations, representative of actual cultivation densities of Douglas fir plantations of central Italy, at ages between 20 and 25 years, mean total volume yields generally lie between 15 and 20 $m^3ha^{-1}yr^{-1}$: 8 $m^3ha^{-1}yr^{-1}$ on poorest sites and 26 $m^3ha^{-1}yr^{-1}$ on the best. These values confirm the high productive potentiality of Douglas fir in Italy on a large range of different environmental conditions.

At the young ages considered, total volume yield is generally greater for denser stands, althought comparative tests at different planting spacings (plantation E) confirm that differences tend to reduce with age.

Growth reponses to tested thinning types lead to the following considerations:

- thinned stands denote higher growth rates than unthinned ones (plantations B and D); plantation C constitutes an exception due to the poor site, indeed thinning on this site proved to be to anticipated since, three years later, crown canopy hadn't yet closed;
- selective thinning types performed better than combined ones (plantations B and C);
- between selective types, low- and crown-thinning showed no significant difference (plantation A);
- among stands with different spacing, best growth reponses to selective thinning have been attained with planting densities around 1000 trees/ha (plantation E).

As a concluding remark it is to be noticed that differences in growth reponse among selective-, combined- and no-thinning treatments tend to vanish if dead and damaged trees are computed in total volume estimates: biomass of these trees has no economic value, but it is quite meaningful from the standpoint of biological productivity of the plantations.

Technical and economic considerations

Occurrence of damaged and/or dead trees has been carefully monitored through periodic controls of experimental areas bringing into evidence that such events are mainly site dependent (frequency and intensity of metereological events like wet-snow, strong winds, etc.). For a given site, different damage (and dead tree) levels are due to treatment: unthinned stands performing

Table 1: Main average data for the treatments within each plantation (volume values, referred to topped stems, are calculated by two-way volume tables and rounded to units).

plantation	planting density (n/ha)	1st inventory (before thinning)					thinning		
		age (yr)	dominant height (m)	mh/qmd[1] (m/m)	density (n/ha)	standing volume (m^3/ha)	type[2]	trees (n/ha)	volume (m^3/ha)
A	3650	19	18.6	95	2071	372	L	402	39
	3650	19	18.7	94	2018	378	C	666	85
	3650	20	18.1	92	1920	368	L	348	34
	3650	20	18.0	93	2008	374	C	584	77
B	2500	17	16.6	87	1991	226	R1/4	737	63
	2500	17	16.2	87	2047	219	L	769	40
	2500	17	15.8	87	2143	242	N	0	0
C	1470	16	11.6	66	1244	113	R1/4	381	31
	1470	16	11.7	66	1169	108	R1/6	330	28
	1470	16	11.8	65	1239	118	L	372	24
	1470	16	11.7	65	1148	114	N	0	0
D	952	18	17.1	64	970	231	L	403	43
	952	18	16.9	68	942	199	N	0	0
E	2104	17	16.9	95	1412	269	L	552	70
	952	17	16.8	78	952	257	L	365	77
	833	19	17.5	78	833	250	L	250	55

(1) mh/qmd = mean height/quadratic mean dbh

(2) N = no thinning; L = selective low thinning; C = selective crown thinning; R1/4 = combined thinning (systematic removal of 1 row out of 4 followed by low thinning); R1/6 = combined thinning (systematic removal of 1 row out of 6 followed by low thinning).

Table 2: Main experimental results (treatments average data measured by the 2nd inventory).

plantation	age (yr)	density (n/ha)	mortality(1) (n/ha)	standing volume (m^3/ha)	c.a.i.(2) (m^3/ha)	total volume (m^3/ha)	m.a.i.(3) (m^3/ha)
A	26	1666	3	611	39.7	650	25.0
	26	1352	0	599	43.7	684	26.3
	27	1548	24	626	41.7	660	24.4
	27	1424	0	584	41.0	661	24.5
B	22	1062	192	261	19.6	324	14.7
	22	1158	120	286	21.4	326	14.8
	22	1763	380	326	16.8	326	14.8
C	19	848	15	128	15.3	159	8.4
	19	839	0	127	15.7	155	8.2
	19	860	7	142	16.0	166	8.7
	19	1136	12	165	17.0	165	8.7
D	24	567	0	362	29.0	405	16.9
	24	884	58	356	26.2	356	14.8
E	25	860	0	412	26.6	482	19.3
	25	587	0	420	30.0	497	19.9
	27	583	0	393	24.7	448	16.6

(1) Naturally dead or totally damaged trees between the thinning and the second inventory.
(2) c.a.i. = standing volume current annual increment.
(3) m.a.i. = total volume mean annual increment.

generally worse and selectively thinned ones best.

Selective thinning considerably reduced damages also in stands that had been severely damaged before thinning. Stand stabilization is due to combined effect of selection (elimination) of weaker trees and increased (diametric) growth of residual ones. Previous studies on the same species in the same areas evidenced that tree stability increases for low height to dbh ratios and for high crown-depth to height ratios, since heavy snow loads are better distributed on each tree (la Marca 1983).

Test sites with less 1000 trees/ha, where height to dbh ratios are on the average low (<80-90) and crown ratios are around 50%, confirm the validity of these parameters as stability indicators since no meteorological damage or dead tree has been registered in such plantations. Obviously thinning and wide planting spacings lead to greater stand mean dbh and tree volume, but tree-branchiness and ring- width of wood (particularly for the first 10-15 years) increase too. Effects on wood quality are currently being examined.

Work productivity of thinning operations (felling, cross-cutting, winch yarding and tractor logging) in comparable conditions differ substantially with thinning type: on the whole combined thinning resulted in a 25-30% economic saving compared to selective thinning (plantations B and C).

Considering single operations'work productivity, on average, differences around 40% have been registered for felling and cross-cutting: advantage of combined thinning is due to reduced time required by tree approaching and for bundle formation.

Single man team productivity has been higher than two men ones: differences are about 14% for selective and 25% for combined thinning.

Productivity of yarding and logging is less influenced by thinning type. On slopes not too steep and with planting spacings wider than 2.5*2.5 meters small tractors can easily move within the plantation, therefore differences between combined and selective thinning for tractor operations'productivity were reduced to 5% in these conditions (plantation C).

In plantation A average per man productivity has been 14% greater for crown- than for low-thinning due to increased mean volume of thinned trees (+30%).

On the whole, given the adequate track network generally available in our Douglas fir plantations, economic balance of first thinning operations is positive if it is performed at ages between 15 and 20 years, thinning more than 25 m^3/ha and yielding sawmill and pallets wood.

However, for the young plantatons investigated, planting spacing has a great influence on thinning return. Economic analysis of operations in plantation E shows that, within given limits, planting densities reduced to 1000 trees/ha are most convenient for the following reasons: greater standing volume of denser plantations doesn't compensate for the high costs they involved; greater tree volume and easier tractor movements allow a higher work productivity; reducing initial density from 2500 trees/ha decrease plantation costs (discounted to the first thinning year) to less than 50% (Figure 1).

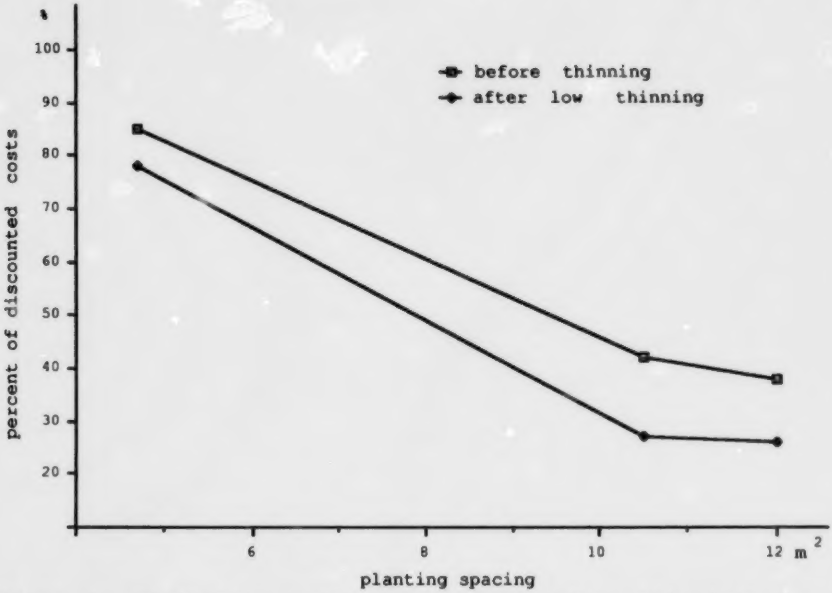

Figure 1: Plantation costs (before and after thinning) as a function of planting density in the plantation E (values, expressed as a percentage of the costs measured in stands with 2*2 meters planting spacing, are referred to planting and silvicultural treatment expenses and are discounted to the 17th year - the thinning year - with an interest rate of 5%).

DISCUSSION AND CONCLUSIONS

Italian experimental thinning trials in young Douglas fir plantations are reported by Ciancio and Nocentini (1978), Ciancio et al. (1980), Avolio and Ciancio (1980), Ciancio et al. (1983), la Marca (1983, 1985, 1986), la Marca and Piegai (1985), Corona et al. (1989a, 1989b). Almost all trials concern first thinning in stands 10 to 30 years old, mostly 15 to 20.

The results summarized above and taken from the Italian literature lead to the following practical conclusions:

a) for average site conditions and planting spacing not narrower than 2*2 meters, first thinning is recommended around 15 years removing 25 to 30% of the standing volume (mean-thinned to mean-before-thinning tree volume ratio is about 0.8, corresponding to an intermediate intensity thinning);
b) for stands on average site conditions, thinning around 15 years, compared to unthinned stands, doesn't significantly

increase stand growth for the following 10-15 years period, but, on the other hand, stands reaching 20 years of age with more than 1000 trees/ha are heavily exposed to wind and snow damages that may severely reduce future yields;

c) as far as growing conditions and volume yields are concerned, superiority of selective thinning types is confirmed since they favor the most vigorous trees directly improving stand present condition and future plantation evolution;

d) from the economic point of view, combined (row plus selective) types may be more convenient for first thinning of young plantations if: planting spacing is less than 2*2 meters, slope inclination is less than 30%, yarding and logging is performed by tractor. In such conditions it is worthwhile to create secondary logging tracks removing one row every 5 or 6 along steepest descent direction. Convenience of combined thinning is greatly reduced if:
   - planting spacing is wider than 2.5*2.5 meters on slopes not stepeer than 30% since in these conditions logging is preferably performed by small tractors less than 1.5 m wide;
   - the slope is steeper than 25% and downhill dry slide logging is possible (with PVC or metal slides);
   - the slope is steeper than 25% and mobile uphill cable logging is possible;
   - the slope is moderate and not too uneven, planting spacing is wider than 2*2 meters and horse logging is possible.

LITERATURE CITED

Avolio, S. and Ciancio, O., 1980: Prove di diradamento in soprassuoli misti per pedali di pino laricio e douglasia. *Annali Istituto Sperimentale per la Selvicoltura*, vol.11, pp.133-162.

Bernetti, G., 1987: I boschi della Toscana. *Edagricole*, Bologna, 177 p.

Cantiani, M., 1965: Tavola alsometrica della Pseudotsuga douglasii in Toscana. *Ricerche Sperimentali di Dendrometria e Auxometria*, vol.4, pp. 32-73.

Ciancio, O. and Nocentini, S., 1978: Prove di diradamento su Pseudotsuga menziesii con il metodo del fattore distanziale di Hart-Becking. *Annali Istituto Sperimentale per la Selvicoltura*, vol.9, pp. 3-33.

Ciancio, O., Nocentini, S. and Tocci, A., 1980: Densità relativa e diradamenti nelle prove comparative di provenienze. *Annali Istituto Sperimentale per la Selvicoltura*, vol.11, pp.231-248.

Ciancio, O., Mercurio, R. and Nocentini, S., 1983: Le specie forestali esotiche nella selvicoltura italiana. *Annali*

Istituto Sperimentale per la Selvicoltura, vol.12-13, pp.1-731.

Corona, P., Farina, A. and Verani, S., 1989: Indagini sperimentali sul primo diradamento di una piantagione di douglasia. *L'Italia Forestale e Montana*, vol.43, no.6, pp.399-419.

Corona, P., Ferrara, A. and Mattioli, M.,1989: Competition measures for the prediction of young Douglas-fir plantation basal area increment. *Proceedings IUFRO S1.05-03 Symposium on Treatment of young forest stands*, Dresden, 18-24.06.89, in the press.

La Marca, O., 1983: Il problema degli schianti nei boschi. Risultati sperimentali su alcuni popolamenti di conifere. *Annali Accademia Italiana di Scienze Forestali*, vol.32, pp.69-114.

La Marca, O., 1985: Sulla densità di coltivazione di alcuni soprassuoli di douglasia. *Cellulosa e Carta*, vol.36, no.4, pp.29-41.

La Marca, O., 1986: Risultati dei primi cinque anni di osservazioni su popolamenti di douglasia (*Pseudotsuga menziesii* Mirb. Franco) sottoposti a prove di diradamento. *L'Italia Forestale e Montana*, vol.41, no.6, pp.333-339.

La Marca, O. and Piegai, F.,1985:Indagini sperimentali su diradamenti in giovani soprassuoli forestali. *Monti e Boschi*, vol.36, no.3, pp.59-71.

Mc Ardle, R.E., Meyer, W.H. and Bruce, D., 1961: The yield of Douglas fir in the Pacific Northwest. *Technical Bullettin* 201 (revision), U.S. Dep. Agric., Washington.

Pardé, J., 1956: Douglas et tables de production. *Annales Ecole Nationale des Eaux et Forets*, vol.15, no.1, pp. 139-175.

Pavari, A. and de Philippis, A., 1941: La sperimentazione di specie forestali esotiche in Italia. Risultati del primo ventennio. *Annali Sperimentazione Agraria*, vol.38, pp.29-44.

Rollison, T.J.D., 1985: Thinning control. *Forestry Commission Booklet* 54, London.

Wiedemann, E. and Schober, R., 1957: Ertragstafeln wichtiger Holzarten. *Verlag M.u.H. Shaper*, Hannover.

January 13, 1990

INFLUENCE ON DIFFERENT STRIP-THINNINGS ON INCREMENT AND STRUCTURE OF NORWAY SPRUCE STANDS

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A schematical thinning experiment was established in a 28 year old spruce stand site class I in the Olpe forest district. The 10 m high stand with a good crown development had a stocking density of 1,0 before the first thinning.

The following treatments with the same thinning degree were carried out after the first cutting:

combined strip- and selective thinning, combined strip and row thinning, pure strip-thinning, unthinned check plot.

Five years later, all thinning plots were subjected to a selection thinning and cut 6 years later in the form of a light low thinning. The annual basal area increment per hectare in the schematical thinning plots was at the age of 39-42 and showed no difference to the control plots.

The crown head room in the thinned plots of the residual trees became 15 years after the first thinning almost overgrown again.

The crown surface area per hectare in these plots exeeded also the value of the control plots, because of the large crown. The strip border trees are the high-class timber in the thinned plots. They developed a special large crown, because of the setting free for many years, and produced the most increment. Also the higher light utilization had an influence on the strip border trees. This was also observed for the trees in the 2nd row, but their increase of increment was lower.

By the treatment "strip thinning", there are 50 % more strip border trees per hectare compared to the other thinning plots. This explains why this type of treatment has better results by the comparison of increment than the other types.

In these schematical examined thinnings, the trees beside the strip lane promoted stand safety concerning volume- and quality increment.

By realisation of such schematical first thinning, it is of main importance to use harvest technics which do not damage the thrifty border trees. Strip width should not be chosen too narrow.

THE IMPACT OF FEDERAL ENVIRONMENTAL LAW ON FOREST RESOURCE MANAGEMENT IN THE UNITED STATES

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FDC: 907: 931: (73)

SUMMARY

The United States has enacted many environmental protection laws during the last three decades that collectively have had substantial impacts on forest resource management. These influences have dramatically increased in recent years as the scope of original legislation has been expanded and as the courts have become more involved in statutory interpretation. This paper provides on overview of the effects of modern U.S. environmental legislation on forest resource management practices. It concludes by examining the current implications and future outlook.

INTRODUCTION

The United States has enacted a plethora of environmental protection laws during the past three decades that have affected forest resource management. This legislation has been prompted by public concerns that unfettered commerce and development have caused damage to the environment, and threatened public health and safety as well. A number of statutes enacted during this period address general environmental protection in some fashion. Others are directed to specific resources. These laws have individually and collectively had a substantial impact on forest management practices. The impact has dramatically increased in recent years as original legislation has been reauthorized and its scope expanded, and as the courts have become more involved in interpreting the meanings of the often broad statutory mandates. In this paper we provide an overview of the influence of modern U.S. environmental legislation on forest resource management practices. We discuss general environmental statutes that affect forest resources, specific forestry and wildlife laws, and the expanding role of the courts in determining legislative intent. The paper concludes by examining the future outlook and implications for forest management.

MAJOR FEDERAL ENVIRONMENTAL LAWS

The list of major federal environmental laws that affect U.S. forest resources is extensive. The more significant of these federal statutes are shown in Table 1.

Some of the laws listed in Table 1 are original statutes that have remained largely unamended, such as the Wilderness Act and the National Environmental Policy Act. Others, such as the Clean Air and Water Pollution Control Act Amendments, were nominally amendments to existing legislation. But the amending laws in the 1970s were by no means minor enhancements; they were substantial, strong new laws designed to protect the environment. In addition, many of the federal environmental statutes passed in the 1970s--such as the Endangered Species Act and the Federal Water Pollution Control Act Amendments--have been reauthorized and strengthened in the 1980s.

Wilderness, Trails, and Scenic Rivers

Regional and national movements to set aside some forests and river corridors as protected natural areas have been pursued in the United States since the beginning of the 20th century. These efforts culminated in passage of the Wilderness Act in 1964, the Wild and Scenic Rivers Act in 1968, and the National Trails System Act in 1968. Each of the three laws was designed to preserve qualifying areas in their natural state--protected from timber harvests, mining, or other development--although these restrictions were phased in gradually in some cases. The National Wilderness Preservation System began with nine million acres in 1964.

With few exceptions, motor vehicles, motorized equipment, motorboats, aircraft, and other mechanical devices are banned from designated wilderness areas. Additionally, natural fires usually are allowed to burn unchecked unless they threaten adjacent lands. Similarly, insect outbreaks and disease are not suppressed in wilderness. These policies are designed to keep the areas natural, but have been widely criticized when lack of protection has led to fire or insect damage on neighboring private forest lands.

The National Trails System Act established a system of trails along historic travel routes and within scenic areas to promote public outdoor recreational opportunities. The Wild and Scenic Rivers Act codified the policy that certain rivers should be preserved in a free-flowing condition to protect outstanding scenic, recreational, geologic, fish, wildlife, historic, cultural, and similar values.

By 1988, the areas designated under all three laws had expanded greatly. The wilderness system, by far the largest, included over 90 million acres; 38.5 in national parks, 32.5 in national forests, and 19.3 in national wildlife refuges.

Table 1. Major U.S. Federal Environmental Laws Affecting Forest Resource Management

1964	Wilderness Act	78 Stat. 890; 16 USC 1131 1136
1965	Land and Water Conservation Fund Act	78 stat 899; 16 USC 4601
1968	National Trails System Act	82 stat. 919; 16 USC 1241-1251
1968	Wild and Scenic River Act	82 stat. 906; 16 USC 1271-1287
1969	National Environmental Policy Act	83 stat. 852; 42 USE 4321, 4331-4335, 4341-4347
1970	Clean Air Act Amendments	69 stat. 159; 42 USC 7401 et seq.
1972	Federal Water Pollution Control Act Amendments	86 stat 816, 33 USC, sections
1972	Federal Environmental Pesticide Control Act Amendments	61 stat. 163-172, 7 USC 135-136
1973	Endangered Species Act	87 stat. 184; 16 USC, various sections
1974	Forest and Rangeland Renewable Resource Act	88 stat. 476; 16 USC 1600-1614
1976	National Forest Management Act	90 stat. 2949; 16 USC, various sections
1976	Federal Land Policy and Management Act	90 stat. 2744; 43 USC, various sections
1980	Alaska National Interest Lands Conservation Act	94 stat. 2374; 16 USC, various sections

Nevertheless, preservation groups have sought to designate a substantial amount of additional acreage under the three laws in order to protect rivers from begin dammed, forests from being cut, wildlife from being endangered, or natural areas from being developed. These efforts have spurred frequent disagreements among preservation and utilitarian interests, as has management of the reserved areas. Many of the disagreements led to court challenges during the late 1960's and early 1970's.

These early decisions served to set the stage for the current wave of litigation. For example, the ruling in Parker v. U.S. [307 F. Supp. 685 (D. Colorado 1969), affirmed 40 U.S.L.W. 2202 (10th Circuit 1971)], which involved the Wilderness Act, had a major impact at the time on the authority of public forest administrators to make management decisions (Siegel 1972). In this case the plaintiffs asked that a proposed national forest timber sale be enjoined until studies were made concerning applicability of the Wilderness Act to the area. They contended that the timber sale acreage should be included in the adjacent primitive area which had been proposed as wilderness under the 1964 Act. The Court held for the plaintiffs and the decision was upheld on appeal.

This case established the concept of "de facto" wilderness--that is, areas of national forest land that are outside of primitive area boundaries but are alleged to meet the definition of wilderness as set out in the Wilderness Act.

The cases of Sierra Club v. Yeutter (661 F. Supp. 1490, D. of Colorado [1987]) and Wilderness Society v. Tyrrel (701 F. Supp. 1473, E.D. of California [1988]) are typical of current litigation. In the former decision, the Court held that reserved water rights are created when national forest lands are designated as wilderness areas pursuant to the Wilderness Act and that the Forest Service must therefore prepare and submit a plan evaluating the alternatives for protecting wilderness water resources. In the second decision, the Court held that a Forest Service plan to harvest burned timber on a national forest, without completing a management plan for an adjacent wild and scenic river, violated the Wild and Scenic River Act.

The National Environmental Policy Act

The environmental movement of the 1960s was marked by skepticism of the role of government in natural resources conservation. As one response, Congress passed the National Environmental Policy Act (NEPA) of 1969, which went into effect in 1970 (Schoenbaum 1982). For every major federal action significantly affecting the quality of the human environment, agencies are required to prepare a detailed statement on the environmental impact of the action; on any adverse environmental impacts that should be avoided; on alternatives to the proposed action; on relationships between short-term use and long-term productivity; and on any irreversible or irretrievable commitments of resources that might occur. These statements must not only be reviewed internally by government agencies, but also by the public.

NEPA and its procedural rules have also provided a substantial basis for federal court litigation. Most cases have been filed by citizen and environmental groups seeking to halt government agency action on the basis that the agency either violated NEPA by not preparing an environmental impact statement (EIS), or that the EIS prepared was inadequate. The court's disposition of these cases has varied from complete dismissal, to requiring preparation or rewriting of an EIS, to temporary or permanent stop work orders being issued (Schoenbaum 1982). Many of these decisions have involved federal forest management activities.

NEPA immediately began to have far-reaching implications for U.S. forest resource management (Siegel 1973). The Forest Service prepared only five impact statements in 1970, but submitted 35 in 1971, 88 in 1972, and 125 during the first four months of 1973. Subsequently, EIS preparation by the agency has continued unabated over the ensuing years. A wide variety of actions have been addressed, ranging from stratification of national forest acreage into management units to expansion of a winter sports area to use of herbicides to control unwanted vegetation in crop tree release. The cost of preparing impact statements is often very great. Management actions must then be delayed, often for many months, while the federal Environmental Protection Agency (EPA) studies the statements and considers the potential environmental effects. To avoid the risk of lengthy and expensive litigation (which often still occurs) and the associated injunctive delays, the government is often forced to prepare statements in doubtful cases. As a result, the cost of implementing many administrative decisions is a severe financial burden.

Air Pollution Control

The Clean Air Act Amendments of 1970 required EPA to set national primary and secondary air quality standards to protect public health. Controls on prescribed silvicultural burning became a particular concern in 1987, when EPA proposed that smoke from such fires must meet a particulate matter size emission standard that could conceivably legally eliminate prescribed burning in some situations. Eventually, however, lobbying by the National Association of State Foresters and the American Forest Council led EPA to revise the standard to comply with conventional prescribed burning practices. This issue is interesting in that limits on emissions from prescribed burning do not permanently eliminate air pollution. To the extent that there are wildfires, the same type of emissions will still occur.

Water Pollution Control

Based on wide-spread perceptions of severe water quality problems, Congress enacted the Federal Water Pollution Control Act (FWPCA) Amendments of 1972. The 1972 law clearly defines point source pollution as any discrete conveyance such as a pipe, ditch, or other identifiable source with a distinct origin. Nonpoint source pollution was not so clearly defined, however, leaving much to administrative interpretation. Over time, agreement has evolved that nonpoint pollution refers to that originating from a widespread land area, such as from silvicultural, agricultural, mining, or construction activities.

Sections 208 and 319--Nonpoint Source Pollution.

Section 208 of the 1972 amendments mandates state planning to control nonpoint source pollution from mining, agricultural, development, and silvicultural activities. EPA originally interpreted Section 208's state planning requirement as applying only to problem areas designated by the governor. However, litigation led to a court decision that Section 208 planning should apply to all areas of the state, including nondesignated forest and agricultural lands (Natural Resources Defense Council v. Train, 396 F. Supp. 1386 [1975].

EPA pursued Section 208 implementation aggressively in the early 1970s. It drafted a model state forest practice regulatory act that included severe controls on forestry practices. Most eastern and southern states have strongly opposed the use of such a water quality implementing mechanism, and have instead developed educational and voluntary best management practice (BMP) systems to control forestry non-point pollution. These state implementing mechanisms are extensively discussed by Haines et al. (1988) and Cubbage et al. (1989).

Despite the efforts that have stemmed from Section 208, many interest groups and members of Congress continued to believe that nonpoint source pollution was still an impediment in achieving the nation's water quality goals. As a result, Congress passed the 1987 Amendment.

A principal component of the 1987 law--Section 319--contains specific language intended to improve control of nonpoint source pollution. Section 319 requires each state to have prepared by August, 1988, detailed water quality management plans that identify bodies of water not in compliance with water quality standards because of nonpoint source pollution. The plans also are required to identify categories and individual nonpoint sources that violate water quality, and to describe control mechanisms. States must then devise either regulatory or voluntary programs to control nonpoint source pollution--including that emanating from forestry activities (Hohenstein 1987).

Several recent court decisions have made it clear that the states have authority to supplement forestry BMPs with their own water quality standards, and that public agencies must comply with state rules concerning nonpoint pollution (Siegel 1987). Most notably, the 9th Circuit Court of Appeals has held the U.S. Forest Service responsible for ensuring that run-off from road building and timber harvesting in the national forests complies with California's state water quality standards (Northwest Indian Cemetery Protection Association v. Peterson, 764 F.2d 581, 795 P.2d 688 [9th Cir. 1985], cert. granted, 107 S. Ct. 1971 [1987]). The Forest Service had argued that the use of state approved BMPs alone fulfilled all obligations under the FWPCA. The Court rejected this argument, finding no indication "that the BMPs were to be considered standards in and of themselves", and further ruling that the BMPs were merely a means to achieve water quality standards.

Section 404--Wetland Point Sources.

Under Section 404 of the FWPCA, forest management activities involving dredge and fill operations in navigable waters and adjacent wetlands may require a permit from the Army Corps of Engineers before commencement. Dredge and fill operations are basically defined as any activity which converts waters or wetlands into dry land, even by the slightest distribution of surface soils (51 Federal Register 41210). The Corps' implementation of Section 404 has been desultory. It initially tried to administratively limit its jurisdiction under the FWPCA to only major rivers and harbors that were capable of carrying commercial traffic

(Stine 1983). Environmentalists brought suit (Natural Resources Defense Council v. Callaway, 392 F. Supp. 685 [1975])--alleging that the Corps minimal Section 404 regulations violated the FWPCA mandate. The Court ruled for the plaintiffs, and instructed the Corps to revise and expand its regulations to protect wetlands and even small streams. The Corps promptly complied, but was initially somewhat unenthusiastic regarding implementation of the broadened requirements (Stine 1983).

The broad judicial interpretation in the Callaway decision of navigable waters and wetlands would have led to permits being required for forestry activities such as logging and road building, even near intermittent streams. The 1977 Amendments to the FWPCA, however, exempted normal silvicultural activities--as well as the construction and maintenance of forest roads when accomplished in accordance with approved BMPs--from the permitting require- ment. Nevertheless, Section 404 is still quite relevant to forestry operations because there is some disagreement as to what constitutes "normal" silvicultural practices (Cubbage and Harris 1988, Cubbage et al. 1987).

In November 1986 the Corps of Engineers issued its final rules on Section 404 dredge and fill permits and other regulatory programs that it administers (Federal Register 51:219, November 13, 1986, pp. 41206-260). These regulations continue to exempt normal silvicultural activities from permit requirements. But they also state that "activities which bring an area into farming, silviculture, or ranching use are not part of an established operation". Such activities, therefore, are not exempt from permit requirements. The regulations additionally state that, while normal harvesting is exempt, "this does not include the construction of farm, forest or ranch roads". In this respect, Section 404 Corps authority may overlap with the provisions of Section 208 as administered by EPA. For example, logging roads and skid trails which meet BMP guidelines established under state Section 208 planning may be exempt if they meet several additional Section 404 criteria.

Endangered Species Protection

To respond to the problems of accelerated habitat destruction and species extinction, Congress enacted the Endangered Species Act in 1973. The Act requires the Secretary of Interior to maintain a list of endangered and threatened species and to insure that those species are protected. All other federal departments and agencies are to make certain that all actions authorized, funded or carried out by them do not jeopardize the continued existence of endangered or threatened species or their critical habitat.

The Endangered Species Act has generated continual controversy relating to forestry and wildlife management on federal lands. It has been applied and used with vigor by wildlife interest groups trying to preserve critical habitat for many endangered species. Two of the more intense controversies have involved preservation of habitat for the spotted owl in the Pacific Northwest and for the red-cockaded woodpecker in the South (Fosburgh 1986). In both cases, national forests have been compelled to substantially revise their forest management plans and reduce timber harvesting in order to provide adequate preservation of old-growth stands to protect the birds' habitat.

Spotted Owl.

In the Pacific Northwest, the Forest Service had designated many old-growth timber areas that were protected from timber harvesting for spotted owl habitat. Environmental groups appealed these plans as providing inadequate protection. In December 1988, therefore, the Forest Service announced that it would establish a network of habitat areas -- ranging from 1,000 to 3,000 acres--in 13 Oregon and Washington national forests, effectively linking old growth areas throughout the two states (Williamson 1988). This 1.6 million acres of connectors was intended to strike a reasonable balance between sustaining spotted owl populations and providing timber supplies vital to the local and state economies. The Forest Service estimated that the annual timber harvest on the 13 forests would be reduced by 180 million board feet per year. However, environmental groups claimed that these set asides, too, were inadequate and filed suit.

The basis of the suit (Seattle Audubon Society v. Robertson, #C89-160 [W.D. Washington]) was that the Forest Service plan was faulty because it did not consider contrary scientific opinion, thereby rendering the supporting environmental impact statement inadequate. After the case was filed, the Court imposed an injunction against 165 timber sales totaling 1.2 billion board feet--nearly half of the annual volume that would ordinarily have been cut in the Pacific Northwest by the Forest Service. The log shortage became particularly acute in the summer of 1989, exacerbated by exports of logs from privately-owned lands to Japan and restrictions on cutting because of fire danger. As a result, mills were forced to curtail operations and dismiss workers. Complaints to Congress mounted.

In October 1989, therefore, Congress passed legislation (P.L. 101-121) as a compromise to the spotted owl controversy. The new legislation places strict limits on injunctions against Forest Service timber sales. It requires the Forest Service to submit to environmental groups a list of planned sales in old growth areas that have more than 40 acres of timber suitable for spotted owls to use. The environmental interests must then identify half of the timber volume on these areas and it will be allowed to be sold. Once this is done, no other federal challenges of the action can be brought.

In the meantime, however, a lawsuit was filed against the legislation on constitutional grounds. The plaintiffs asserted that the restrictions imposed on new lawsuits against timber sales are unconstitutional in that they violate the separation of powers doctrine which limits the right of Congress to prohibit court review. On November 6, 1989, however, the federal district court for the Western District of Washington upheld the constitutionality of the legislation and lifted the injunction against the timber sales.

The spotted owl controversy has not been confined to the Forest Service. The Bureau of Land Management was also under a court injunction for many months prohibiting cutting on much of that agency's land in Oregon. The injunction (Portland Audubon Society v. Lujan, # 87-1160 [District of Oregon]) was finally lifted by the 9th Circuit Court of Appeals. The Bureau also obtained relief for many of its sales in P.L. 101-121--similar to that granted to the Forest Service. In December 1989, the constitutionality of P.L. 101-121 was also upheld by the Oregon Federal District Court.

Red-Cockaded Woodpecker.

Like spotted owls, the red-cockaded woodpecker in the South also depends on old-growth pine forests for its habitat, and has been listed as an endangered species. Most private forest landowners in the South have cut their old-growth pine stands; only the Forest Service manages extensive pine acreage on long rotations. Additionally, the Endangered Species Act has thus far been interpreted to apply only to land management on federal lands. Thus the primary responsibility of providing adequate woodpecker habitat has fallen on the Forest Service. The issue of timber harvests versus woodpecker habitat preservation is a difficult one.

The southern national forest plans developed in the 1980s did provide some habitat protection, but many wildlife interest groups did not consider it adequate. The Sierra Club thus brought suit against the Texas National Forest plans in 1988. The federal court (Sierra Club v. Lyng, 694 F. Supp. 1260 [E.D. Texas 1988]) ruled that no clearcutting could occur within 1,200 meters of any red-cockaded woodpecker colony. This represents an area of about 480 hectares (1200 acres) for each known active bird colony. The decision, which severely restricts timber management and harvesting on large areas of the Texas National Forests, has been appealed by the Forest Service. Furthermore, in 1989, the Sierra Club notified the Forest Service that it would bring suit regarding woodpecker habitat on all relevant southern national forests. This caused the Forest Service to alter its current plans to provide greater woodpecker protection in hopes of avoiding that suit. So instead, the American Forest Resource Alliance, a forest industry trade association, filed suit against the Forest Service for changing the existing management plans for southern forests.

Overall, the Endangered Species Act provides a powerful tool for protecting endangered species, but it can also severely disrupt commercial timber as well as other forest resource activities. To date, the Act's requirements regarding habitat management apply only public lands. Private landowners may not, of course, kill any endangered species. But the possibility of the extension to habitat management on private lands, especially for protection of endangered plant species, is feared by private timberland owners and land developers.

Forest Resource Planning

As the preceding review indicates, broad federal environmental protection laws have had a substantial impact on forest resource management practices on public and private lands in the United States. In addition, many specific federal forest resource laws have addressed both public and private forestry. The two most significant of these specific statutes are the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 and The National Forest Management Act (NFMA) of 1976. Each addresses the management of the 190 million acre National Forest System, and each is integrally linked to environmental protection and planning on national forest lands.

The public participates in the formulation of forest plans, and individuals or groups may file administrative appeals to plans they deem unsatisfactory. Prior to enactment of the planning legislation, public participation consisted primarily of comments on draft environmental impact statements or procedural challenges to management decisions under NEPA. Today, the provisions for participation under NEPA are supplemented by the provisions for administrative appeals of forest plans (36 C.F.R. 211, 219 [1987]) and for appeals of specific management decisions.

Dissatisfied citizens may also seek judicial review of plans, thus removing them from the administrative appeals process. This litigation may be based on violation of RPA/NFMA, failure to prepare an adequate EIS under NEPA, inadequate protection of species listed under the Endangered Species Act, or for a variety of other reasons. The environmental laws have combined with the national forest planning process to provide fertile grounds for litigation.

CONCLUSIONS

As this review clearly indicates, national environmental laws and forestry laws with environmental provisions have had a substantial impact on forest resource management in the United States. These statutes have been designed to protect a broad range of environmental benefits--including water and air quality, common and endangered species, timber production, and recreational opportunities. At the same time the number of court cases initiated to require stricter implementation of environmental legislation is increasing rapidly.

On federal lands, in particular, the vigorous implementation of environmental protection laws--coupled with extensive public input and frequent litigation by environmental groups -- is causing substantial changes in resource management. Timber harvesting and commercial development are rapidly losing their dominance. National Forest and Department of Interior land managers must now carefully balance resource use and resource protection. Although local interests may often favor commercial use of public lands, they now must contend with strong general public support of the environment and with national laws designed to protect nonmarket values. Indeed, the legislative balance may well have shifted from unbridled development with little thought for the environment to a focus on environmental protection and natural area preservation, with little concern for economic returns or commercial interests. Even where commercial uses remain important, however, they are becoming increasingly regulated.

Federal land management laws do not directly regulate private lands. Nevertheless, their impacts are still important. The federal water pollution control laws have prompted states to use voluntary BMPs or forest practice regulatory acts to protect forest water quality from nonpoint source pollution. These BMPs/forest practice acts may address timber harvesting practices, logging road construction, chemical applications, or streamside timber harvesting and residual stand conditions. Federal and state air quality laws also have led to regulation of prescribed burning in many states. Herbicide and pesticide regulation also indirectly affects private land management practices, by governing which chemicals may be used for silvicultural practices.

The scope of current federal law is likely to be expanded by legislative amendment, judicial review, and administrative discretion. How can U. S. forest resource managers respond to this trend? Their actions now will determine the latitude available in the future to manage public and private forests for both market and nonmarket goods. Forest users and managers who favor preservation or nonmarket goods and services are likely to support stronger environmental protection statutes. On the other hand, forest managers who favor commercial uses such as timber growing, developed recreation, mineral extraction, and hunting may oppose further legal controls.

Environmental groups have vastly outspent and have outmaneuvered forest industry groups. Many such organizations actively pursue administrative rulings and judicial interpretations of existing legislation that will favor their positions. The forest industry, on the other hand, has just begun to develop a cohesive legislative strategy and has seldom initiated litigation. But as this review suggests, the courts will be crucial in determining the allowable degree of freedom for practicing forest management and harvesting timber in the years ahead. Preservationists will prefer to restrict autonomy; utilitarians to maximize professional discretion.

LITERATURE CITED

Carson, Rachel. 1962. Silent Spring, Houghton Mifflin. Boston. 368 p.

Cubbage, Fred and Thomas Harris, Jr. 1988. Wetlands protection and regulation: federal law and history. TOPS 22(1):18-23. Georgia Forestry Association. Atlanta.

Cubbage, F.W., Siegel, W.C. and Haines, T.K. 1987. Water quality laws affecting forestry in the Eastern United States. In: Proceedings of the Symposium on Monitoring, Modeling and Mediating Water Quality, American Water Resources Association. p. 597-609.

Cubbage, Frederick W., William C. Siegel, and Peter M. Lickwar. 1989. State water quality laws and programs to control nonpoint pollution from forest lands in the south. In, Proceedings, AWRA 1989 Conference on Water: Laws and Management. Technical Publication 89-4. American Water Resources Association. p. 8A-29 to 8A-37.

Fosburgh, Whit. 1986. Wildlife issues on the National Forest System. In: The Audubon Wildlife Report 1986. The National Audubon Society. New York. p. 159-173.

Haines, T.K., F.W. Cubbage, and W.C. Siegel. 1988. Recent developments in state water quality laws affecting forestry in the East. In: Proceedings, 1988 Environmental Conference. TAPPI. Atlanta. p. 457-467.

Hohenstein, William G. 1987. Forestry and the Water Quality Act of 1987. Journal of Forestry 85(5):5-8.

Rey, Mark. 1980. The effect of the Clean Water Act on forestry practices. Presented at: Symposium on U.S. Forestry and Water Quality: What Course in the 80's? Sponsored by the Water Pollution Control Federation. June 19-20, 1980. Richmond, VA. mimeo. 20p.

Schoenbaum, Thomas J. 1982. Environmental Policy Law. The Foundation Press, Inc. Mineola, New York. 1065 p.

Siegel, W.C. 1972. Environmental law and forest management. Journal of Forestry 70(11):682-686.

Siegel, W.C. 1973. Environmental law--some implications for forest resource management. Environmental Law 4(1):115-134.

Siegel, W.C. 1987. The interaction of state and federal water quality legislation in the United States--implications for forest practices. In: Report of IUFRO Working Party S4.08-03: 195-211.

Stine, J.K. 1983. Regulating wetlands in the 1970s: U.S. Army Corps of Engineers and the environmental organizations. Journal of Forest History 27(2):60-75.

Williamson, Lonnie L., Editor. 1988. Outdoor News Bulletin 42(25) 1-2. Wildlife Management Institute. December 16.

SMALL MULTI-FUNCTION MACHINES AND MULTI-TREE HARVESTING IN FIRST THINNINGS

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SUMMARY

Small stem size, low areal yield, good silvicultural practice result, as well as ergonomic criterias set great demands for machines in first thinnings. Efficient machines are available for clear cutting and later thinnings, but because of the high capital cost, they tend to be uneconomic in early thinnings.

Two approaches can be applied to reduce the costs of first thinnings. We can develop machines for processing simultaneously several trees, or we can develop smaller machines with lower capital costs. These two alternative solutions were studied in a joint Nordic project during 1987-1989.

Multi-tree harvesting has a great development potential. Some one-grip and two-grip harvesters, even if they were not designed for multi-tree harvesting, could handle 2-4 trees at a time with a reasonable delimbing result. The greatest potential for multi-tree harvesting seems to be in one-grip harvester heads. A multi-tree processor has been developed also for a farm tractor. The target areas for multi-tree harvesting are stands with a sufficient number of stems to be removed per hectare.

Small harvesters were also studied in the project. The width of these machines is under 2 metres and weight 6-7 tons. The distance between forwarding strip roads in the Nordic countries is typically 30 metres. Small harvesters also can operate between these strip roads. The performance of small multi-function machines is sensible for conditions. In first thinnings with stem size of 50 litres and removal of 40 m^3/ha the output of 3-meter pulpwood is about 4-5 m^3/effective hour. The silvicultural thinnings result of these machines is good. They thus offer a lighter alternative for mechanizing first thinnings.

Keywords: Thinning, mechanization, multi-tree harvesting

METHODS FOR PROJECTING TIMBERLAND AREA

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SUMMARY

Changes in timberland area must be projected to assess the forest resource situation in a country or region. To reliably estimate resource supplies, models must be capable of projecting two types of changes in land area: (1) land use by ownership class and (2) major forest cover types by forest ownership class. The models used for United States projections are described, and research is recommended for improving the models.

Keywords: land use, econometric model, land base

INTRODUCTION

Because forests and forest products are important and take so long to mature, societies need reliable long-term projections of supplies of and demands for forests and their products. These projections provide opportunities to anticipate and alter or adjust to potential undesirable resource conditions and price trends.

This paper describes modeling of changes in timberland area for supply projections in the United States. Changes in timberland area are crucial to the supply projections, and to be most useful the changes must be divided by forest type and ownership class. Division by forest type permits application of standard formulations for estimating yields of forest products. Division by ownership class permits reasonable estimation of future forest treatments because different types of owners tend to treat their forests differently. In existing projection systems, transitions among age classes are projected by the inventory model and transitions among site classes are based on extrapolation of historical trends (USDA Forest Service 1990).

This paper emphasizes use of area change models for the projection of timber supplies. The same models, however, are needed to project supplies of other forest-based resources, such as cattle forage, wildlife and fish habitat, and recreation opportunities (e.g., USDA Forest Service 1988).

Area change models project the quantity and quality of land available in future years for producing timber. Changes in the area of forest are major determinants of changes in net annual timber growth, timber inventory, timber supplies, and other forest-based outputs. Because projected changes in forest products markets are sensitive to assumptions about future changes in forest area (Alig and others 1983), changes in forest area can affect production costs, stumpage prices, regional land values and, eventually, financial returns from forest investments. That is why information on changes in forest area, including detail on forest ownership, forest cover types, and land productivity (site) classes, is important in timber supply modeling.

For this discussion, timberland is defined as forestland that can produce 1.4 cubic meters of industrial wood per hectare per year and that is not withdrawn or reserved for other uses. In 1987, in the U.S., timberland comprised around two-thirds of the forestland. Because of its importance for timber supply, two types of changes in timberland area were projected: (1) land use by class of forest ownership (timberland versus other major land uses), and (2) area changes by forest types and ownership class.

LAND USE BY OWNERSHIP CLASS

Modeling of the land-use component of timberland area change must focus on the major competing land uses--forestry, agriculture, and urban and developed uses. Changes in land use such as clearing for agriculture, clearing for development, and planting or natural seeding of trees on former agricultural land strongly influence the total area in forest. Within the forestry component, there are shifts of ownership that must be accounted for. Each broad owner group--government, forest industry, and nonindustrial private--has different land management tendencies.

Relationships among land uses have been estimated by econometric methods or from expert opinion approaches (Alig and others 1990). Either approach must consider demands for land by competing sectors of the economy.

Econometric techniques have increasingly been used to quantify the relationship between economic, demographic, and policy variables and categories of land use in the U.S. (e.g., Alig 1986). Economic principles help to guide selection of appropriate explanatory variables, and population and personal income have consistently been significant variables across U.S. regions (Alig and others 1990). Changes in government programs also help to explain land exchanges between the forestry and agricultural sectors.

AREA CHANGES BY FOREST TYPE

Projecting changes in the areas of forest types requires simultaneous modeling of forest disturbances or treatments and forest vegetation dynamics. Failure to account for forest succession, particularly that which frequently occurs after harvest, can lead to incorrect conclusions about future resource production. For example, timber production by nonindustrial private owners in the Southern United States cannot be closely estimated without accounting for passive reforestation of harvested pine stands and succession to hardwoods.

Alig (1985) described a general modeling approach for projecting area changes among forest types. A Markov model projects the areas of forest types that will result from a designated mixture of custodial care, harvesting, and other miscellaneous forest management activities, and forest succession. Probabilities of forest type change over time are summarized in matrix form, and the form of each forest type change probability is:

$$P(D_{k(i,j',t)})\ P(FT_{i,j,t+1} \mid D_{k(i,j,t)}). \qquad [i=1,\ldots,n;\ j=1,\ldots m;\ t=1,\ldots s]$$

Expressed is the probability of a disturbance of type k on ownership i and forest type j in decade, multiplied by the conditional probability that a unit area of timberland on ownership i at decade t+1 will be in forest type j', given the disturbance. In this way, the probability of land in a forest type remaining in that forest type, or changing to any other given forest type, is determined. Probabilities used in these calculations are determined from inventory remeasurment data of the USDA Forest Service. Future forest type areas, by decade, are projected by multiplying an initial vector of forest type by the transition probability matrix.

If sufficient data on disturbances do not exist for a region and suitable plots have been remeasured at least once, simpler probabilities can be computed:

$$P(FT_{i,j',t+1} \mid FT_{i,j,t}).$$

These probabilities are an average over all disturbance regimes (including no disturbance) and ownership groups, and are estimated from sample relative frequencies. If no time series data exist, projections are based on opinions of regional experts.

RECENT APPLICATION

Area categories used in modeling forest-vegetation and land-use dynamics in the Southern U.S. for the 1989 Resource Planning Act (RPA) Assessment by the USDA Forest Service (1990) were:

Region	Ownership	Management Type
Southeast	National Forest	Pine plantations
South Central	Other public	Natural pine
	Forest industry	Mixed pine-hardwoods
	Farmer	Upland hardwoods
	Miscellaneous corporate	Bottomland hardwoods
	Other individual	

These categories or area cells are the most detailed ones used in the 1989 RPA Assessment because less data were available for other regions.

Associated models in the U.S. for projecting area changes also are the most highly developed for key timber supply regions, such as the South.

In the 1989 RPA Assessment, area changes models were translated into timber resource projections with three closely related sets of models. The Timber Assessment Market Model (TAMM) produced estimates of roundwood harvest and the Aggregate Timberland Analysis System (ATLAS) estimated changes in timber inventory, growth, and removals (USDA Forest Service 1990). Changes in timberland area by ownership and forest type were simulated with area change models patterned on a prototype Southern Area Model (SAM) for the U.S. (Alig 1985). The same basic assumptions about key factors such as growth in population, income, economic activity, and investments in forest management were used in all sets of models.

The TAMM-ATLAS-SAM model system is the first generation of an integrated area-change, timber-inventory, and timber-supply model for nationwide application in the U.S. Area models in SAM provide estimates of area change by forest ownership and by forest cover type to ATLAS. Regional timber inventories are projected by ATLAS; timber inventory is used, in turn, in projecting regional timber supply in TAMM. Several sequential simulations are required to produce a consistent set of timber supply projections because simultaneous feedback mechanisms have not been fully defined. For example, work is underway to internalize forest type transitions in the next-generation model for projecting timber inventory. Timber management activities projected by ATLAS are used in modeling area changes in forest cover types, and estimates of area changes in land use rely on projections of timber prices produced by TAMM. As one might expect, the difficulty of model solution increases as the complexity of the modeling system increases.

Because of uncertainty about future changes in land use, and particularly about changes in excess agricultural production capacity in the United States, alternative futures were simulated to show the impacts on the timber resource situation from alternative assumptions about future changes in timberland area (USDA Forest Service 1990). For example, in one alternative the amount of marginal cropland and pasture land that could be economically suitable for pine plantations over the next several decades was estimated. In this manner, the sensitivity of projections to certain assumptions was examined and a wide range in possible land use shifts was considered.

SUMMARY AND FUTURE DIRECTIONS

Models that project forest area change by ownerships and forest types have been utilized in increasingly sophisticated models of timber inventory and timber supply. Models projecting timberland area change, timber inventory, and timber markets have been linked to produce an integrated projection system. This modeling system reflects an improved understanding gained through regional research studies of the factors that determine area change, as well as improved modeling techniques.

In future studies of the allocation of land to alternative uses, we must pay greater attention to the increasing interdependence of national economies throughout the world. The decision to use land for forestry or agriculture in the United States is based, in part, on world markets for forest and farm products. Ideally, we may eventually develop methods, if not models, that incorporate the indirect role of trade in domestic land use.

In addition, for our models to be more useful for policymakers, we must incorporate explicitly the role of forest and agriculture policies in land allocation. Sometimes by design, but often by accident, policies formulated for one sector have a significant impact on the other. One objective of future forest area change modeling should be a better understanding of the role of agricultural policies in land-use decisions.

In the United States, forest sector modeling has evolved from reliance on relatively simple growth and yield models to use of more sophisticated systems for projecting timber inventory, timber management and investment, timber harvest, and land allocation. Integration of these systems has been improved by enhanced data on land resources and forest land ownership. Quantity and quality of data must continue to improve, however, if we are to develop models with the greater detail needed by policymakers. For example, time series of data on land management would provide for richer tests of hypotheses to support model development.

LITERATURE CITED

Alig, R.J., Adams, D.M., and Haynes, R.W., 1983: Long-range projections of forestland area change: New approaches are needed. Journal of Forestry, vol. 81, 723-727.

Alig, R.J., 1985: Modeling area changes in forest ownerships and cover types in the Southeast. USDA Forest Service Research Paper RM-260. Rocky Mountain Forest and Range Exp. Stn., Ft. Collins, CO. 18p.

Alig, R.J. 1986: Econometric analysis of forest acreage trends in the Southeast. Forest Science, vol. 32, no. 1, 119-134.

Alig, R.J., Hohenstein, W.G., Murray, B.C., and Haight, R.G., 1990: Trends in timberland area in the United States by State and ownership, 1952-1987, with projections to 2040. USDA Forest Service, General Technical Report SE-in press. Asheville, NC.

USDA Forest Service. 1988: The South's fourth forest: Alternatives for the future. Washington, DC. Forest Resources Report No. 24. 512pp.

USDA Forest Service. 1990: An analysis of the timber situation in the United States: 1989-2040. USDA Forest Service General Technical Report RM-in press. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

December 28, 1989

FOREST SECTOR MODELING TECHNIQUES: HOW DO THEY INFLUENCE POLICY RECOMMENDATIONS?

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SUMMARY

The past two decades have seen major advances in the analytical techniques with which industrial sectors have been examined, and through which alternative futures for these sectors have been explored. The primary objective of the models used to support sector analysis has been to describe--with more or less detail--the structure of the sector, and to focus policy discussions to better understand likely futures, both with, and without intervention. With multiple models to choose from, it is reasonable for model users to ask whether the model chosen will influence the policies recommended.

There are now a number of examples of "fully defined" models of the forest sector--that is, models with breadth (geographic, and sector output) and detail (specifying within-sector production and consumption decisions, and interaction among market levels). These include the Timber Assessment Market Model [TAMM] (Adams and Haynes, 1980), and the Global Trade Model [GTM] (Dykstra and Kallio, 1987). Comprehensive sector analysis has also been supported by less completely specified models. The "consistency analysis" of the fourth European Timber Trends and Prospects Study [ETTS-IV] (United Nations, 1986) is an example of this approach to modeling.

Forest sector models force us to organize our data, our assumptions, and our expectations for the future in a consistent framework. Because they are abstractions based on numerical representation we are also forced to quantify any factors we wish to include explicitly, and express the relationship between these and other market relationships. In these critical features all sector models are similar.

Although there are differences between models in the specification of economic relationships, and differences in the manner in which key market indicators (such as prices and quantities) are computed or projected, most forest sector models share a basic philosophy concerning the fundamental determinants of future conditions. Simply stated, we assert that relative costs determine competitive advantage, and relative prices determine desireable markets.

As forest sector models have evolved and forest sector modelers have gained and shared both experience and data, differences in data series critical to all sector analysis have diminished. The differences between sector models--largely matters of technique and style--are less important than are key assumptions and data. To the extent that data and assumptions can be standardized we can expect similar policy recommendations from different approaches to sector modeling.

Adams, Darius M.; Haynes, Richard W. 1980. The 1980 softwood Timber Assessment Market Model: structure, projections, and policy simulations. Monograph 22. Forest Science. 64 p.

Dykstra, Dennis P.; Kallio, Markku. 1987. Introduction to the IIASA forest sector model. In Kallio, M.; Dystra, Dennis P.; and Binkley, Clark S. (eds.). The global forest sector: an analytical perspective, pp 615-625. New York: John Wiley & Sons. 703 p.

United Nations. 1986. European timber trends and prospects to the year 2000 and beyond. Geneva: United Nations and Economic Commission for Europe. (2 vols.). Vol. I. 323 p.

THE U.S. PULP AND PAPER MODEL

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ABSTRACT

The U.S. Pulp and Paper Model is an economic model of the pulp and paper sector. It simulates the adoption of new pulp and paper manufacturing processes and simultaneously projects the prices and quantities of pulpwood and wastepaper consumed in the United States and Canada. The model encompasses production and trade of the United States and Canada with respect to each principal grade of pulp, paper, and paperboard, hardwood and softwood pulpwood, and several grades of recycled wastepaper. This report describes the context in which the U.S. Pulp and Paper Model is being developed, and provides a general description of methods and research that are being incorporated in the model.

INTRODUCTION

The U.S. Pulp and Paper Model is being developed by the USDA Forest Service to assess long-range supply and demand for pulpwood in the United States in relation to economic growth, trade, and likely technological changes, such as increased use of wastepaper for recycling. The Forest Service is required by congressional legislation to provide periodic assessments of forest resources in the United States, including analysis of the supply and demand for timber.[2] The most recent assessment was completed in 1989 and the next assessment is scheduled for completion in 1993.

Research in support of the most recent assessment included development of an economic model of the U.S. and Canadian pulp and paper sector, previously referred to as the Forest Products Laboratory (FPL) Pulpwood Model. In this paper, the improved version of the FPL Pulpwood Model is referred to as the U.S. Pulp and Paper Model because it is designed specifically for use in the 1993 resource assessment. The model provides 50-year projections of technological change in the pulp and paper sector, and projections of future pulpwood consumption

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[1] The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin. This article was written and prepared by U.S. Government employees on official time, and it is therefore in the public domain and not subject to copyright.

[2] See Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (P.L. 93-378, 88 Stat. 476, 16 U.S.C. 1600-1614).

and prices in the United States (see Ince and others 1987, Howard and others 1988). We used the model to examine various scenarios for future technology, including one that assumes an accelerated use of wastepaper in North America (Howard and others 1989). In comparison with many other timber market scenarios that we examined for the 1989 assessment, we found that accelerated wastepaper use could have a very significant impact on future timber prices and consumption patterns in the United States.

Wastepaper recycling has become a major social and political issue in the United States because of mounting concerns about disposal of municipal solid waste, shortfalls of permitted landfill capacity, and rising landfill costs. A comprehensive report on the municipal solid-waste problem in the United States was recently prepared by the United States Congressional Office of Technology Assessment (OTA 1989). Findings of this and other studies point logically to a future in which strong pressures will accelerate the use of wastepaper for papermaking in the United States.

How will the use of wastepaper accelerate in the United States and what are the likely consequences for domestic timber markets? These are the kind of questions that require an analytical tool such as the U.S. Pulp and Paper Model. This economic model is the means by which we will specify detailed assumptions regarding technology change and recycling, and by which we will project the economic consequences in domestic timber markets for the 1993 resource assessment. The model may be used for other purposes as well, such as analysis of joint U.S. and Canadian issues or separate analysis of the Canadian pulp and paper sector.

METHODS

The U.S. Pulp and Paper Model is a spatial equilibrium model, as conceptualized in general by Samuelson (1952). The modeling framework is based on the Price Endogenous Linear Programming System (PELPS) developed originally by Gilless and Buongiorno (1985). As such, the model contains a linear programming formulation of the spatial equilibrium problem (see Duloy and Norton 1975), and it uses "recursive programming" (Day 1973) to find year-to-year solutions for the market equilibria. In this system, it is assumed that the optimizing behavior of the free market can be simulated as the maximization of consumer and producer surplus among all markets and regions in the model.

On the demand side of the model, demand functions represent North American and overseas demands (such as Europe and Asia) for each of the principal grades of paper and paperboard products produced in the United States and Canada. Demand functions include elasticity with respect to North American price and with respect to change in demand determinants, such as projected population and gross national product (GNP). On the supply side, regional U.S. and Canadian supply functions represent pulpwood supply for hardwood and softwood, and wastepaper supply for several principal grades of wastepaper. Supply functions include elasticity with respect to price and with respect to projected regional timber inventories or projected recovery volumes of wastepaper raw material.

In addition, the model includes an endogenous representation of regional U.S. and Canadian production capacity and supply for all principal grades of pulp, paper, and paperboard. Furthermore, regional production capacity for each product is divided among one or more competing processes. These include current processes and processes that will become available for production at assumed future dates. Product supply functions consist of the production capacity existing each year among the various processes and the production costs of each process for the various regions. Capacity growth is allocated to the most economically efficient processes and regions each year, with exogenous constraints on capacity growth. The interaction of the exogenous demand functions and the endogenous supply functions determines the equilibrium solution for product markets in the projection period. The model also includes an endogenous solution of the regional supply and demand equilibrium for pulpwood and wastepaper, with regional demand determined by raw material requirements of production processes and the simultaneous equilibrium solution for paper and paperboard production.

As fiber raw material markets change during the projection period and as new production technologies are introduced in the model, the regions and processes that experience the most capacity growth can change as well. Thus, as technology for utilizing wastepaper and the supply of wastepaper are projected to change over time, the model will simulate the economic allocation of wastepaper recycling capacity in the pulp and paper sector. It will also simultaneously estimate the future supply and demand equilibrium for pulpwood and wastepaper in the United States (and Canada).

RESEARCH

Several preliminary studies are needed to address some key questions related to the future of wastepaper supply and recycling technology. We encourage others interested in collaborating or supporting this research to contact us directly.

Wastepaper and Recycling Research

Modeling future wastepaper supply is one area that needs additional research. Much research has already been done on institutional aspects of wastepaper supply, including estimates of the volumes of wastepaper generated in the U.S. economy, limitations on waste disposal capacity, infrastructure capabilities, and alternative technologies for disposal of wastepaper (see OTA 1989). Development of precise wastepaper supply functions for each principal grade of wastepaper will involve further research on more detailed questions related to availability of wastepaper for recycling:

> In what time frame will specific regions lack landfill availability so that alternatives to landfilling will become mandatory or inevitable?
>
> What precise quantities of wastepaper, by principal grade of wastepaper, go to regional landfills?
>
> How much wastepaper is recoverable for recycling in each region? What costs are associated with recovery and transportation of wastepaper furnish from one region to another?
>
> To what extent will current mandatory source separation laws and other legislative initiatives increase regional supplies of wastepaper (by principal grade of wastepaper)?

Research in this area will examine the volumes of wastepaper generated in various regions by principal grade of wastepaper, infrastructure capabilities, costs of recovery and transportation, alternative disposal technologies, and legal developments likely to influence wastepaper supply functions. We will then develop appropriate supply functions for wastepaper in the U.S. Pulp and Paper Model.

Modeling current and future production processes is another research area that needs to be addressed. Current technological constraints and future developments will determine the production processes represented in the U.S. Pulp and Paper Model. Developing accurate process assumptions involves answering various questions related to wastepaper recycling technology:

How will technological developments increase the proportions of recycled wastepaper that can be accommodated in each principal grade of paper and paperboard?

How will production costs be affected in each grade?

When will improved production processes become available in the model?

What legislative mandates will affect papermaking technology (such as mandates on consumer purchase of recycled products or minimum recycled fiber content)?

How will these mandates affect production costs?

Research in this area will involve an extensive review of the technical literature on likely technological, legal, and institutional developments that may affect the future of wastepaper utilization technology. We will then develop specific assumptions about current and future input requirements and production costs for the various production processes incorporated in the U.S. Pulp and Paper Model.

Model-Related Research Topics

Additional research is underway to improve the general structure and capabilities of the U.S. Pulp and Paper Model. Research areas include study of overseas trade (to and from North America) in the principal grades of pulp, paper, paperboard, and wastepaper. The model will include overseas supply and demand functions to represent exogenous trade flows. One question is to what extent will the overseas demand for wastepaper change in the future? Of particular interest is the growing importance of wastepaper export from the United States. Our research will include estimation of overseas demand functions for wastepaper exported from North America. Important questions concern the sensitivity of the overseas demand for wastepaper with respect to domestic prices and exchange rates. Demand functions in the model relate to North American prices and can be adjusted to simulate projected changes in the exchange rates.

Other areas of research that will improve the U.S. Pulp and Paper Model include additional research on North American demand functions for paper and paperboard products, improved mechanisms for dealing with intertemporal constraints on capacity expansion, and development of computerized process models to investigate the effects of technological changes on production processes.

LITERATURE CITED

Day, R.H. 1973. Recursive programming models: a brief introduction. In Studies in Economic Planning Over Space and Time: Contributions to Economic Analysis, G.G. Judge and T. Takayama, eds., American Elsevier, New York, pp. 329–344.

Duloy, J.H., and R.D. Norton. 1975. Prices and incomes in linear programming models. Am. J. Agric. Econ. 57(4):591–600.

Gilless, J.K., and J. Buongiorno. 1985. PELPS: Price-endogenous linear programming system for economic modeling. Report R3329. Univ. of Wisconsin–Madison, College of Agric. and Life Sci., Madison, WI. 34 p.

Howard, J.L., P.J. Ince, I. Durbak, and W.J. Lange. 1988. Modeling technology change and fiber consumption in the U.S. pulp and paper industry. In Proceedings of the 1988 Southern Forest Economics Workshop, Abt, R.C., ed., Orlando, FL. May 4–6, 1988. University of Florida, Gainesville.

Howard, J.L., I. Durbak, P.J. Ince, and W.J. Lange. 1989. Analysis of future high levels of wastepaper use in regional pulpwood markets in the United States. In Proceedings of the 1989 Southern Forest Economics Workshop, Potter, R.H., ed., San Antonio, TX. March 1–3, 1989. Champion International, Huntsville, TX.

Ince, P.J., K.E. Skog, H. Spelter, I.A. Durbak, and J.L. Howard. 1987. Modeling technological change in wood products processing. In Forest Sector and Trade Models: Theory and Applications: Proceedings of an International Symposium, Cardellichio, P.A. and others, eds., Seattle, WA. November 3–4, 1987. Center for International Trade in Forest Products, Univ. of Washington, Seattle.

OTA. 1989. Facing America's trash: What's next for municipal solid waste. U.S. Congress, Office of Technology Assessment, OTA-0-424. Washington, DC: U.S. Government Printing Office. 377 p.

Samuelson, P.A. 1952. Spatial price equilibrium and linear programming. Am. Econ. Rev. 42(3):283–303.

A COMPARATIVE EVALUATION OF A GLOBAL OPTIMIZATION MODEL AND A NATIONAL SIMULATION MODEL

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FDC: 722.1--01

ABSTRACT

After the end of the Forest Sector Project at IIASA in 1985 two Austrian forest sector models have been developed. The "Austrian Model of Production, Consumption and Trade in Forest Products (ATM)" is an optimization model based on the structure and software of the IIASA "Global Trade Model" (GTM). The "Simulationmodel of the Austrian Forest Sector (FOHOW)" is a simulation model using the System Dynamics language. Both models have similar features: they try to cover the entire forest sector, from wood increment to paper consumption, they are long term oriented and their main goal is to answer "what ... if ?" questions rather than to make forecasts. Beside the general approach the models differ significantly in scope: the ATM is a global model with nine regions and fourteen forest products, the FOHOW is a national model with only two regions and nine products. A comparative evaluation of both models is undertaken on the following levels: general model approach (optimization - simulation), implementation (handling, system control, aggregation, data, model presentation), conceptual issues (general market representation, interactions between regions and products, demand, supply, trade), and potentials for improvement. The main conclusion to be drawn from the comparative evaluation is that none of the two models is better than the other in absolute terms; both have their various strengths and weaknesses. Which one is to be preferred depends on the specific issue to be analysed. ATM and FOHOW should be considered as a first generation of models, which need both to be improved in order to make their potential for forest sector analysis fully available.

STRUCTURAL CHANGES OF THE FOREST SECTOR - CHALLENGES FOR ANALYSIS AND EVALUATION OF FOREST POLICIES

by

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FDC: 903: 91--01

SUMMARY

Changes in the forestry sector have always occurred but the pace of this evolution seems to increase today. Globalization of the economy, population growth, concerns for the environment and the quality of life, the information and technological revolutions are all factors that impact directly the forestry sector. A sector model needs to integrate the important elements which allow to simulate the impacts of these changes for forestry as well as the policy responses to them. An important policy variable in this regard is the use of the land which can be guided by a panoply of policy instruments affecting directly or indirectly forestry uses. Such policy tools can be evaluated relatively easily by monitoring land use which reflects the socio-economic and political reality impinging on the biophysical characteristics of the land.

Keywords: Sector analysis, forest policy, land use, incentives, evaluation.

INTRODUCTION

Our world is changing fast today, and so is the forestry sector and the forest. The environment and forestry were front news last year in Paris during the annual Economic Summit of the seven major industrial nations. The communique cited the "urgent need to safeguard the environment for future generations" and "threats to the atmosphere which could lead to future climate changes; growing pollution of air, lakes, rivers, oceans and seas; acid rain; and rapid desertification and deforestation". The final summit declaration strongly endorsed the Tropical Forestry Action Plan and the International Tropical Timber Organization and recognized the role that debt forgiveness and debt-for-nature swap can play in promoting environmental protection. All relevant international organizations were asked to complete reports on the state of the worlds forests.

This renewed concern for the environment of which forestry is an important component, is not the only drastic change that took place since last IUFRO congress. The swift transformation of the centrally planned economies toward more democratic systems of government and liberal economies, the globalization of the economy, trade and finance, the continuation of the electronic and information revolution, are all new or accentuated trends that we, as sector modelers and political scientists, need to incorporate in our analyses.

After reviewing briefly the changes occurring in the forestry sector and their effects on sector and policy analysis, we will show how these changes can best be handled by paying due consideration to the use of the land. Land use is seen as an important factor in sector analysis and to implement given forest policies. We conclude on the necessity to refine the sector analysis by paying due consideration to land use changes so that alternative forestry policies can be easily simulated for their effects on prices and production levels.

NEW TRENDS IN THE FORESTRY SECTOR

The forestry sector analysis has traditionally encompassed the study of timber production and consumption leaving aside all the non-timber outputs provided by the forest: water, animals, environmental benefits, recreation... The new concerns for the environment and the quality of life, force us to consider all these outputs in our sector analysis. Lets review some important trends related to the demand, the industry, trade and the supply aspects of forest outputs.

Concerning demand on the forest resources, regional population growth stays the top issue for forestry as well as all other sectors or our global economy. Today, the population of the world is over 5 billion. There are more people on this earth than ever before and more people are added to the world's population each year than ever before in history. Nearly 75 percent of the world's population now live in less developed countries where 75 percent of the world's population live but where only 65 percent lived in 1950. The number of people added each year is increasing even though birth rates have begun to fall moderately. If world fertility remained at 3.8 - child family average, what would the population be in the year 2100? 51 billion people (Interchange, 1984). Another important exogenous variable influencing the demand of forest products and forest services, income per capita, is still increasing but at a decreasing rate with 1.9, 2.1 and 3.6 percent for the present and past two decades in developed economies and 3.9, 3.2 and 1.8 percent for developing countries in average but with negative -1.3 growth rate for indebted countries and a 4.6 percent for exporters of manufactures in the 80's. The issue is income distribution. Log prices have been increasing slightly but constantly due to the disappearance of old growth forests. Nevertheless, the increase in trade and the creation of new plantations should damp this trend. Values of non-timber outputs is increasing faster than timber prices in developed economies and the environmental values of the forest cover in tropical areas may surpass by much the value of the standing timber.

The development of new wood products continues to improve the efficiency of the industrial process and allows the use of small diameters, low quality wood, and fiber (medium density fiberboard panels). The use of wood for producing chemicals will increase while the higher use of all, fuelwood, will continue. Prices of sawnwood are increasing while those of panels and pulp have decreased reflecting improvements in the industrial processes and increase in production capacity and so economies of scale. Bioengineering and electronics should keep improving the efficiency of the transformation process.

Historical trade routes are maintained, Canada - US, Scandinavian - Europe, Africa - Europe, East - Asia - Japan, US - Japan while new countries as Brazil, Chile, South Africa, Oceania emerge as exporters of their plantation outputs. The exports from tropical countries will decrease as old growth vanishes and the domestic markets expand. The USSR seems ready to offer part of their siberian old growth to the highest bidder. China may become a very important importer of logs and wood products. However, multiple tariff and non-tariff barriers as well as a non-transparent market are constraining trade. The fluctuations in exchange rates have negative impacts in the short run for some countries but should not influence trade in the long-run (Roberts, 1989). Transport costs should stabilize as competitiveness increase through the creation of new free trade zones, such as the EEC, and deregulation. GATT is seen more and more as the multilateral forum to resolve trade disputes and set the rules of the game. They create ITTO.

Concerning the supply of timber and forest products, one can lament the lack of fiable statistics. The forest area shrinks rapidly and often irreversibly in tropical countries to expand agriculture, satisfy fuelwood needs, and increase old growth timber and products export. In developed economies the non-timber attributes of the forest increase in value and many forest area become semi-urbanized decreasing the harvest level in the process as the objectives of forest management evolve.

The salient feature of this superficial overview of the factors affecting the structure of the forest sector is that our world and regions are in an accelerated period of flux. Models of the forestry sector must be able to incorporate the elements allowing to simulate the effects of these new trends so that policy analysts can use them to test different scenarios of government responses to these changes. An important policy variable that should be included in such models is the use of the land, a topic to which we now turn.

LAND USE AS A FOREST POLICY VARIABLE

In this state of flux,one factor of the forest sector is almost immutable, land. However its use can be guided in very many ways to impact the demand and the supply of forest products and services. For instance, precluding harvest on sensitive wetlands can be done through legislation, the government power to tax or by eminent domain. Instigating harvest or management on a piece of private forest land owned to satisfy non-timber objectives can be done through the provision of incentives, or a tax stick, or both. Increasing the forest area could be done through income-tax breaks for new afforestations as it has been done so successfully in Brazil, Chile and Great Britain. Increasing property taxes on certain types of land can damp the demand for them. Many other direct and indirect policy instruments exist to plan or guide the use of the land that is not publicly owned (Harou, 1990). Under public ownership, a politically acceptable land use plan can be followed. The approach to land use should be multisectoral as any sectoral incentives, to agriculture land for instance, is likely to have an impact on forest land too.

The link between forest sector analysis, forest policy and land use is better depicted in figure 1. This organigram which is developed in more details elsewhere in this proceedings (Harou and Essmann, 1990) can be summarized as follows. The world land suitability for forestry and other uses impacts, through our global economy, the local socio-economic and political system. This system interacts with the local biophysical suitability of the land to set the context for the forestry and other sector analyses. Under these particular conditions, the supply and demand of all forestry outputs bring about prices or values which are used to establish the B/C of the forestry use and of the intensity of its use. Other non-efficiency objectives varying by ownerships are also considered before comparing the final forestry use with other uses. After the comparison with other uses, millions of decisions are made in a given area which are reflected in a certain land use pattern. Such uses are monitored over time and may be changed through the political process if the present trend is judged socially unacceptable. Such land use policies can be implemented through different land use policy tools some of which we alluded to earlier. To the extent that the new land use policies are properly implemented through well focused policy instruments, the national socio-economic context is changed and will impact the forest sector which in turn should bring about the desired changes by influencing prices, values, land availability, costs or by constraining the use of the land to particular use.

The evaluation of this policy or the effectiveness its programs can be done relatively easily by comparing the social costs of the new programs with a quantitive or qualitive assessment of the land use changes brought about by the new policies. For example, the social costs of an income tax-break to afforest can be compared to the resulting planted area over a certain period of time. This area can be translated in a new supply over time which impact can be simulated by a forestry sector model and mapped by GIS. Damages to the environment can be evaluated similarly. The monitoring of rapid and damaging forest conditions by deforestation or air pollution can awake public and political opinions and force political actions if the resulting effects on the forestry sector and the economy as well as on the use of the land can be simulated and mapped. The impact of changing agriculture policies can also be evaluated by monitoring land use.

The proposed approach to design and evaluate new forest policies by reference to the use of the land has the great advantage of being integrative in nature. Because the resulting use of a parcel of land is reflective of the interaction between its biophysical characteristics and all the socio-economic and political factors impinging on it, focusing forest policies on the use of the land should permit to react to most of the structural changes affecting the sector, whatever the changes and their pace.

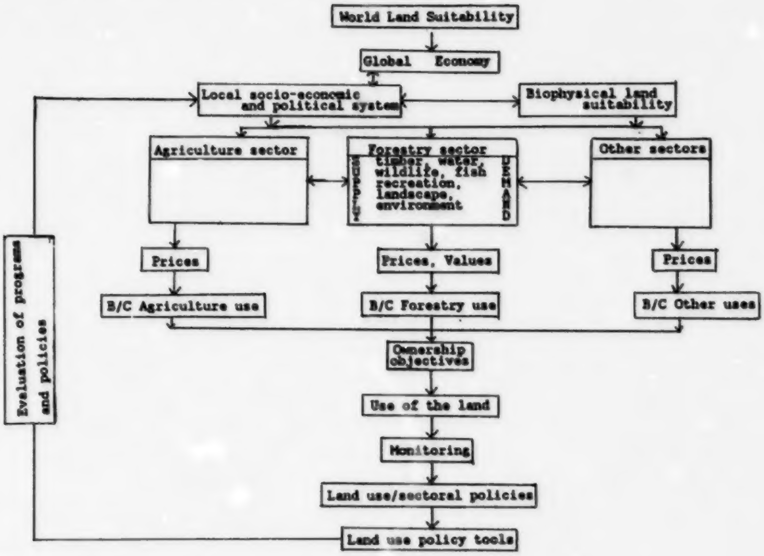
CONCLUSIONS

The changes we are witnessing today are occurring faster than before, but they have always occurred. To guide them, the forestry sector analysis, being global or local, need to be updated periodically and comprehensive so to allow for the simulation of many trends not only in the environment and the global economy, but also in the use of the land. Such a sector model will be a good policy analysis tool to simulate impacts on prices and quantity of policy variables such as the exchange rate, interest rate... but also on some preconceived alternative patterns of land use. Once a new land use pattern is agreed upon and some policies established to reach the objectives and targets set, the programs initiated to implement them should be easily evaluated following the land use cycle explained in figure 1.

Here we would like to conclude with two recommendations for the IUFRO working group on sector analysis. The first is to propose a standard method, even if imperfect, to do a sector analysis for individual countries. This analysis should be simple but allow for refinements if the information is available and its easy integration in an aggregated regional or global model. An accepted general procedure for forestry sector analysis would help implement the tropical forestry action plan (TFAP). Presently many sectoral policies offered in the TFAP are not grounded on a thorough sector analysis required to prioritize forestry investments. Furthermore because of the absence of some standard, comparisons of forestry sectors among countries are difficult to do, and so will the comparison of forestry investments. The second recommendation is to keep the IIASA global forest sector model initiative alive. Even if some judge the final product of limited usefulness for practical purposes, the initiative should help improve international statistics and fine tune the methodology of sector analysis, a useful policy analysis tool, over time.

An indirect benefit of these two recommendations would be the creation of an active epistemic community of forest scientists able to help the policy-makers on the urgent decisions to be made regarding forest resources throughout the world, including pollution and deforestation. Many uncertainties surround these decisions. Under such circumstances, specialists play a significant role in attenuating such uncertainty. Information is at a premium and leaders seek authoritative advice to lower this level of uncertainty. Traditionally, states have been impervious to technical advise, which was usually subordinated to shorter-term political concerns. Studies found that experts tended to be coopted or defused by able politicians. Yet, if the group of specialist share a common world view, or set of cause-and-effect relations, they are likely to be particularly influential because they will resist the political temptations to subordinate their advise to existing political concern (Haas, 1989). This group of IUFRO scientists, constitutes an international epistemic community and could prove influential in defining the dimensions of a problem and hence privileged in identifying likely solutions.

Figure 1 - Sector and policy analyses linkage to land use.


World Land Suitability
Global Economy
Local socio-economic and political system
Biophysical land suitability
Agriculture sector
Forestry sector
timber, water, wildlife, fish recreation, landscape, environment
SUPPLY
DEMAND
Other sectors
Prices
Prices, Values
Prices
B/C Agriculture use
B/C Forestry use
B/C Other uses
Ownership objectives
Use of the land
Monitoring
Land use/sectoral policies
Land use policy tools
Evaluation of programs and policies

Source: adapted from Harou 1990a and Harou and Essmann 1990b.

LITERATURE CITED

Anonymous, 1984. The fundamentals of population growth. Interchange 13(4):4.

Haas, Peter M. 1989. Politics of International Environmental Cooperation. In Technology-Based Confidence Building. July 9-14, 1989. Santa Fe, New Mexico (in press).

Harou, P.A. 1990a. Forestry taxes and subsidies for integrated land use on private lands. In Whitby, M.D. and P.J. Dawson. Land use for agriculture, forestry and rural development. Proceedings 29th EAAE Seminar July 5-7, 1989. UK (in press).

Harou, P.A. and H. Essmann. 1990b. Integrated land use and forest policies - a framework for research. In Div. IV Proceedings. IUFRO World Congress, 1990. Montreal, Canada.

Roberts, D.G. June 1989. Exchange rate changes and international competitiveness of the Canadian softwood lumber industry. Economic Branch of Forestry, Canada. Working paper 17p & annexes.

World Bank, 1989. World Development Report 1988. Oxford University press. Washington, DC. 307 p.

THE CHANGING STRUCTURE OF THE INTERNATIONAL TRADING SYSTEM: SOME IMPLICATIONS FOR U. S. FOREST PRODUCTS TRADE

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FDC: 742.11: 722.1: (73)

The international trading system has been experiencing a major restructuring in recent years and nowhere do the changes appear to be more significant than in the European Community. Initially established by the Treaty of Rome in 1957, the European Community has since developed and expanded to become today a twelve-nation group formally comprising a common market. As a common market in principle, the EC nations subscribe to an agreement whereby there is an absence of trade restrictions among the members, a common tariff schedule pertaining to third nations, and the free movement of labor and capital within the market. The impetus behind its formation was a desire to attain, through the elimination of trade restrictions, the higher productivity that is made possible by more efficient geographical distribution of production and economies of larger-scale production.

The Community's first major goal, the elimination of tariffs between the member countries, was achieved over the decade following the Treaty of Rome. Subsequent to that, the two remaining general policies necessary for the establishment of a common market were agreed upon and put into place. These are the establishment of a common tariff schedule applicable to nonmember countries and the freeing of capital and labor movement within the Community. Although the Community thus appears to fulfill the requisites of a textbook example of a common market, there are a number of areas unrelated to tariffs where there remain significant barriers to the free movement within the Community of goods, services, and resources. Unemployment remains high in a number of countries, and slow economic growth has raised additional concerns. In addition, there have appeared disturbing signs of acrimony in the EC budget-setting process as well as in the resolution of disputes, particularly those related to agriculture, within the Community.

These factors provided the impetus for a concerted program to remove as many of the remaining obstacles to a true common market as possible, and resulted in 1985 in the issuance of the "White Paper" by the Commission of the EC. The member nations became officially committed to the White Paper proposals with the enactment in 1985 of the "Single European Act," the only major amendment to the Treaty of Rome.

1992 AND THE COMPLETION OF THE INTERNAL MARKET

In addition to reforming governance of the EC, the Single European Act commits the member nations to the achievement of a set of specific policy reforms designed to bring about substantial liberalization of relations between the members by the end of the year 1992. Referred to by the term "completing the internal market," the implementation of the changes has received widespread publicity in the EC nations and enjoys a high degree of political and popular support. Many barriers which have persisted despite the formal status of the EC as a common market are targeted for removal under "EC92." Lengthy border formalities result in costly delays for both individuals and transported goods. The delay of commodities is largely due to the problems associated with collection of the value added tax (VAT) which is assessed at different rates in different countries. Excise taxes on some products also vary widely between the nations with resultant delays in transportation. Technical, safety, health, and environmental standards also vary from country to country. In addition, there remain impediments to the movement of professional labor and the provision of professional services. Banking, insurance, and other financial services are also subject to a variety of regulations that impede their international provision. Notably absent from the problems addressed by the call for completion is any plan for a concerted effort to address the troublesome agriculture issues that impinge upon trade. The major issues under this category are within the purview of the EC's Common Agricultural Policy, and are not covered by the plan for completing the internal market.

The reforms called for in the White Paper are specified in the form of 285 measures which are classified into three general categories: the removal of physical barriers, the removal of technical barriers, and the removal of fiscal barriers (Commission of the European Communities, 1985). However, we will take these up under the categories of tax and government expenditure reforms, technical and quality standards, and regulatory policies.

Value added tax harmonization is intended to reduce the variability of tax rates of the member nations by specifying ranges within which VAT rates are to fall. Tax harmonization has two purposes with respect to completion of the internal market: the reduction in border delays caused by the system of VAT rebate/assessment mentioned above and the reduction in the incentive of economic agents to locate activity in a socially wasteful manner in order to avoid higher taxes. Subsidies which distort trade are already illegal. Strictly speaking, this should mean in effect that virtually all subsidies are illegal. In practice this means that those subsidies that are not exempt (as is agriculture) and that have the more readily identifiable trade impacts are subject to EC sanctions. The White Paper calls for an inventory of state subsidies with a view toward more stringent enforcement in this area. The final area involving government budgets is public procurement, where the intent is to place both supply and construction contracting on a more competitive international basis. Measures call for increased requirements for open advertising by government agencies, expansion of coverage to areas previously exempted, and enhanced enforcement by allowing aggrieved parties access to a more effective appeal process.

The technical and quality standards category may be thought of in terms of both those relating to products and those relating to the professional qualifications of individuals. The problems associated with a multiplicity of product technical standards are to be alleviated by the setting of general performance standards to apply uniformly throughout the EC (i.e., "harmonization") while the principle of mutual recognition is to apply to professional qualifications of individuals to practice within the EC in nations other than where they were trained. Skilled labor qualifications will be treated by harmonization through the international standardization of vocational qualifications.

The final general category deals with harmonization of a wide range of regulatory controls and policies covering both product and service industries. The major controls on short-term capital movements within the Community will be substantially liberalized by financial market harmonization (Calingaert 1988, pp. 51-53). Policies as diverse as regulation of corporate mergers, antitrust laws, environmental and phytosanitary regulations and public health related food packaging standards for paper and paperboard are all to be harmonized. It is anticipated that over 40 directives will apply to the standardization of regulations to prevent the spread of plant diseases.

UNITED STATES FOREST PRODUCTS TRADE AND 1992

The United States, Finland, and Sweden are closely bunched for second place in world forest product exports, each exporting only about half the value of Canada. The United States is also the world's leading forest products importer. In the U.S. in recent years forest products imports have exceeded exports by upwards of 40 percent. In the past 20 years U.S. forest products exports have grown at an average rate of about 4-1/2 percent per year, about the same as the rate of growth of total U.S. exports. Real growth at this rate is respectable--somewhat more rapid than the growth rate of real GNP--and reflects a growing importance of world trade both in forest products and goods in general. Recent values of the major categories of U.S. forest products exports and imports are shown in Table 1. The last two columns of Table 1 give a general idea of the relative magnitude of trade in the different product groups. Although for the nation as a whole this might be considered a rough index of the relative importance of trade in the broad categories, the data mask the impact of trade on sub-industries and regions.

The European community nations constitute a major market for U.S. forest products exports. In five of the nine product categories shown in Table 2, exports to the EC comprise over one third of U.S. total exports. Any major changes in EC policies such as those projected by the completion of the common market have the potential to greatly affect the trade situation of third countries such as the U.S. Further, both positive and negative effects can be expected.

Growth in income of the EC nations as a whole can be expected to increase the demand for goods in general, including imported forest products. The growth effect is likely to have two components: the one-time increase in aggregate income resulting from putting into place the market completion measures, and the higher basic growth rate of aggregate income resulting from institutional changes that allow resources to be channeled more efficiently on a long-term basis. The effect on U.S. exports to the EC depends on the magnitude of the effects and the income responsiveness of EC demand for U.S. forest products.

A major study (Cecchini 1988) estimates various economic impacts, and projects an eventual (one-time) change in the level of EC gross domestic product of between 4 1/2 percent and 7 percent. This effect, combined with the neutral assumption that imports of U.S. forest products will increase proportionally is used to obtain an idea of the order of magnitude to be expected in increased U.S. exports to the EC. Multiplying the values in Table 1 by the percentages in Table 2, summing and applying the estimated change in gross domestic product gives an increase in forest products exports of between $118 million and $184 million based on 1987 export volumes and values. The increased exports break down as follows:

sawnwood	$45.4 - 70.7 mil
wood pulp	38.3 - 59.5
paper and paperboard	16.6 - 25.9
wood-based panels	14.1 - 21.7
hardwood logs	3.6 - 5.6

Of course, these estimates are only roughly suggestive. Over a long period, the cumulative effect of the market completion on EC income growth will tend to have a greater relative impact than is obtained above.

SOME U.S. CONCERNS

U.S. exporters appear to be advantaged since it is easier to compete in a market area with only a single product standard than dozens. However, this is a benefit enjoyed by countries within the Community as well as third country exporters to the EC. The estimates above assume that the U.S. forest products exporters in a sense share proportionately in the growth brought by the 1992 measures. Another way of looking at this is to ask whether competitive EC and third country suppliers are likely to gain more or less than those in the U.S. The possibility of discriminatory forest products standards being established by the harmonization process creates the potential for less than proportional gains, or even losses, in U.S. export volumes. The measure which will have the greatest impact on forest products trade is the Construction Products Directive (Statement for the Record of NFPA 1989) under which a large number of wood and wood-based materials standards are to be harmonized. Pursuant to the directive, the European Committee for Standards (CEN) is developing proposals through a number of committees which are working closely with industry representatives from the member countries. Technical committees are dealing with a number of areas relevant to forest products trade. Directives relating to standards and tests for paper and paperboard products will result from recommendations of a number of other technical committees.

It is of concern to the U.S. that members of the European Free Trade Area (EFTA) outside the EC are participants in the standards setting process of the CEN committees, since this includes, among others, Finland and Swede Standards and test procedures which give preferential treatment to the EFTA nations would have a negative impact on the U.S. export position.

Table 1. U.S. Exports and Imports of Major Forest Products, 1987.

Product Category	Exports ($ Bil)	Imports ($ Bil)	Net Trade Balance ($ Bil)	Exports as Share by Volume of U.S. Production (percent)
Roundwood	1.9	.1	+ 1.8	4.3
Sawnwood	1.4	3.0	- 1.7	7.1
Panels	.4	1.0	- .6	4.1
Wood Pulp	2.3	1.8	+ .5	8.1
Paper and Paperboard	2.2	5.9	- 3.7	6.1
Total	8.1	11.8	- 3.7	

Source: FAO Forest Products Yearbook, 1987.
Note: Totals may not agree due to rounding.Import figures were multiplied by .913 to obtain approximate values less c.i.f.

Table 2. Major Forest Product Exports to European Community Nations as a Percentage of Total U.S. Exports, 1987.

Product	Percent of Total Exports	Product	Percent of Total Exports
Particleboard	79	Fiberboard	27
Softwood Lumber	76	Hardwood Lumber	26
Plywood	68	Paper and Paperboard	17
Hardwood Logs	38	Softwood Logs	0
Wood Pulp	37		

Source: FAO Forest Products Yearbook, 1987.
Note: Percentages are calculated on the basis of volume or weight.

REFERENCES

Calingaert, Michael 1988. The 1992 Challenge from Europe: Development of the European Community's Internal Market, Washington, DC, National Planning Association.

Cecchini, Paolo 1988. The European Challenge 1992, Gover Publishing Company.

Commission of the European Communities 1985. Completing the Internal Market: White Paper from the Commission to the European Council, COM(85) 310, June 14.

Statement for the Record of The National Forest Products Association Europe 1992 Program for the US Government Working Group on European Community (EC) Standards, Testing and Certification, International Trade Administration, International Economic Policy, Department of Commerce, Hearing Held July 26, 1989.

December 1989

MODELING FOREST SECTOR DYNAMICS:
CHALLENGES FOR FUTURE ANALYSIS

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FDC: 722.1: 903--01

SUMMARY

This paper summarizes experience and highlights future analytical challenges related to modeling four dynamic features of the forest sector: forest inventory, capacity adjustment, demand dynamics, and policy formation.

Keywords: Forest sector models, dynamics

INTRODUCTION

Applied forest economics research in the 1980s was dominated by forest sector modeling. "Forest sector models" are defined as supply/demand models used for long-run forecasting and policy analysis. They generally contain two submodels: a forest model, for keeping track of roundwood growing stock, and a market model, for predicting product prices and quantities. The market model usually includes both roundwood and processed products.

Many of the challenges facing economists involved in forest sector modeling relate to dynamic, or time-dependent, processes. In this paper we discuss modeling issues related to four dynamic features of the forest sector: forest inventory, capacity adjustment, demand dynamics, and policy formation[1].

FOREST INVENTORY

Short-run roundwood harvest is typically modeled by a supply (marginal cost) curve whose position depends on the quantity and sometimes the composition of the forest resource. Forest inventory (stock adjustment) models of varying degrees of complexity link these short-run relationships between periods. Long-run roundwood supply is then determined by the pattern of short-run harvests over time and by the impacts of harvest levels and management investments on forest growth.

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[1] Principal contributions by each author were as follows: Brooks (forest inventory), Cardellichio (capacity adjustment), Haynes (demand dynamics), and Vincent (policy formation).

Because forest sector models are typically intended to serve as market-simulating models that describe observed rather than optimal behavior, forest inventory models tend to be based on descriptive rather than optimizing principles (Larson and Goforth 1974, Tedder *et al.* 1983, Brooks 1987). Although progress has been made in representing how the interaction among biological, economic, and policy variables affects forest dynamics, current modeling approaches face several persistent problems. These problems relate to: 1) using forest survey data that are often not collected or compiled for systematic modeling, 2) balancing the detail needed to represent biological determinants of growth with the aggregation needed to be consistent with the market model, and 3) characterizing the impact of harvesting and management activities on forest growth and yield.

The past two decades of grappling with these problems have resulted in larger, more elaborate models. Unfortunately, the most notable consequences of using these models in large-scale, long-term simulations have been the identification of data inadequacies and the exposure of weak assumptions. This experience reflects the fundamental need for better representation of the structural characteristics of forests.

Future research efforts could be deployed fruitfully in at least two directions. First is the linkage between long-term forest development and short-term management responses to specific policy instruments, such as forest regulations, tax policies, and incentive programs. Second is the interaction between roundwood production and the provision of other forest-related goods and services. At the very least, models should attempt to capture the impacts of roundwood harvesting on nonwood forest resources.

CAPACITY ADJUSTMENT

Processing capacity is essential in defining the position of the marginal cost curve for a processed product and therefore in determining its price. Even the definition of capacity, however, can be problematic: is it the level of output where price equals minimum average total cost (where there is no incentive to alter capacity), or the maximum level of output? Most forest sector models use the latter definition.

While it may be possible to obtain measures of historical capacity levels for heavily concentrated industries such as pulp or newsprint, capacity data often must be inferred from the analysis of related market variables. The "trend-through-peaks" method is commonly used for this purpose. It provides a quick and simple method for generating capacity estimates, but it has obvious limitations: 1) the number of peaks may be few in the short time series typical of forest sector data, 2) utilization rates to calibrate different peaks are difficult to assign, and 3) capacity levels between peaks cannot be estimated accurately.

Capacity adjustment is generally linked to profitability in forest sector models. One way to model this relationship is to generate a capacity adjustment series by first-differencing the capacity series, and then to use this as the dependent variable in a regression equation. This approach faces several statistical problems: 1) errors-in-variables caused by trend-through-peaks, 2) limited variability in the capacity adjustment series, 3) too short series for estimating switching regression models, and 4) complicated lag structures.

Alternatively, one can develop decision rules and select parameters to conform with empirical evidence and expert judgment. In the Pacific Rim Assessment Model (Cardellichio *et al.* 1989), capacity is modeled as having a tendency to adjust to its optimal level, i.e. where price equals minimum average total cost. Differential adjustment parameters account for the downward rigidities that cause a capacity decrease to be slower than an increase of the same magnitude. The capacity adjustment parameters critically affect the model's behavior: for example, whether Japan is forecasted as reducing imports of softwood logs, hardwood logs, or both depends on the choice of capacity adjustment parameters.

DEMAND DYNAMICS

Models of demand for forest products in the U.S. have developed along two different lines. The oldest line of research is the "use-factor" approach pioneered by economists in the USDA Forest Service prior to World War II. This approach, which was applied primarily to solid-wood products, involved disaggregating consumption into end-use categories that had relatively homogeneous demand characteristics. Projections of consumption were made by combining exogenous forecasts of end-use activity with judgmental estimates of use-factor trends thought to be consistent with future movements of relative prices and consumer tastes.

The second line of research employs basic factor demand theory and econometric methods to estimate empirical demand functions. In this approach, demand functions shift through time as a function of changes in exogenous variables such as population, income, and end-use activity (e.g., housing starts). These econometric models, especially the early ones, tend to address product categories that are much more aggregate than those in use-factor models.

Current demand models--for example, the one used in the 1989 RPA Timber Assessment (USDA 1988)--merge these two lines of research. As represented in the work by Cardellichio and Veltkamp (1981) and Spelter (1985), demand models are specified with the use factor as a function of relative prices and an array of qualitative indicators of consumption preferences. Price variables may involve distributed lags or "cost put in place." Products are disaggregated by end-use category for solid-wood products and by grade for fiber products. Total consumption is obtained by multiplying each use factor by its activity measure and summing over all end uses. Demand schedules shift from period to period due both to changes in the activity measures and to price-induced substitution between products.

Demand dynamics will take on special importance in the future as policy makers focus more attention on demand-altering policies than on supply-augmenting policies. Analysts increasingly will need to develop models that can accommodate changes both in major demand determinants and in end-use patterns. Preference for the modern use-factor approach is uncertain to continue: the desire for models with more product detail is constrained by rising costs of collecting time-series data on consumption by end use. The less data-intensive econometric approach may experience a resurgence in popularity in coming decades.

POLICY FORMATION

The standard approach to policy analysis treats policy instruments as exogenous variables and assesses them in terms of their impacts on endogenous variables. Forest sector models' reliability as policy analysis tools is affected by the issues considered in previous sections, but they suffer two, more fundamental, limitations as well. We discuss these limitations in the context of international trade policies, but the discussion is pertinent to forest sector policies more broadly defined.

The first limitation is the models' narrow forest sector focus. Most models are designed, essentially, to track wood flows from forest to consumer. Other important economic sectors are excluded, most notably the labor market. This exclusion can have severe consequences for trade policy analysis, because: 1) trade issues often relate to the employment impacts of foreign competition, and 2) the economically most efficient policies for addressing trade problems are usually not trade interventions, such as tariffs and quotas (which distort both production and consumption decisions), but domestic interventions, such as wage supports, training programs, or subsidized credit. The consequences are much greater for analysis of dynamic aspects of policies.

The second limitation is the models' treatment of policies as exogenous (model input) instead of endogenous (model output). Policy endogenous models offer three potential advantages over policy exogenous models: 1) identification of optimal policies, 2) better understanding of the policy-making process, and 3) more accurate forecasts of market conditions resulting from future economy/policy interactions. The first advantage is a natural extension of current practice and is easily achieved: instead of evaluating a predetermined set of alternative policies, the optimal policy is determined by specifying an objective function and using programming techniques to solve for the policy instruments that optimize this function, subject to market equilibrium conditions (Fair 1984). Vincent (1989), for example, solved for welfare-maximizing tariffs on tropical roundwood and processed products.

Progress in realizing the second and third advantages is limited at this time to theoretical models that incorporate the actions of self-interested lobbyists and legislators (Magee *et al.* 1989). These models demonstrate that "directly unproductive" activities like lobbying for protection can reduce social welfare beyond the reduction due to a tariff itself. They also help explain the predilection for trade interventions over domestic interventions. Empirical counterparts of these theoretical models might lead to better analysis of situations like the low rate of capacity utilization in the tropical sawnwood industry, which may be a "rent-seeking" response to policies governing allocation of timber harvesting rights.

The initial step toward policy endogeneity should be to modify existing forest sector models to yield optimal policy levels. At the very least, this will provide analysts with additional insight into model behavior. The more challenging task of explicitly modeling policy formation should first be explored via empirical frameworks (e.g., detailed industry studies) that involve less abstraction and aggregation than do forest sector models.

LITERATURE CITED

Brooks, D.J., 1987: SPATS: a model for projecting softwood timber inventories in the southern United States. *Research Paper* PNW RP-385, Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, 23 p.

Cardellichio, P.A., Youn, Y.C., Adams, D.M., Joo, R.W., and Chmelik, J.T., 1989: A preliminary analysis of timber and timber products production, consumption, trade, and prices in the Pacific Rim until 2000. *CINTRAFOR Working Paper* 22, College of Forest Resources, University of Washington, Seattle, Washington, 97 p.

Cardellichio, P.A., and Veltkamp, J., 1981: Demand for Pacific Northwest timber and timber products. Study Module II-A, Forest Policy Project, Pacific Northwest Regional Commission, Vancouver, Washington, 285 p.

Fair, R.C., 1984: Specification, estimation, and analysis of macroeconomic models. Harvard University Press, Cambridge, 479 p.

Larson, R., and Goforth, M., 1974: TRAS: a timber volume projection model. *Technical Bulletin* 1508, USDA Forest Service, Washington, D.C.

Magee, S.P., Brock, W.A., and Young, L., 1989: Black hole tariffs and endogenous policy theory. Cambridge University Press, New York, 438 p.

Spelter, H., 1985: A product diffusion approach to modeling softwood lumber demand. *Forest Science*, vol. 31, no. 3, pp. 685-700.

Tedder, P., Gourley, J., and Lamont, R., 1983: The Timber Resource Inventory Model (TRIM). Unpublished report, Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon.

USDA, 1988: An analysis of the timber situation in the United States: 1989-2040. USDA Forest Service, Washington, D.C., 400 p.

Vincent, J.R., 1989: Optimal tariffs on intermediate and final goods: the case of tropical forest products. *Forest Science*, vol. 35, no. 3, pp. 720-731.

January 3, 1990

STRUCTURAL CHANGES OF THE FOREST SECTOR IN A GLOBAL PERSPECTIVE-CHALLENGIES FOR FOREST POLICY DESIGN

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FDC: 903: 907

SUMMARY

The global concern appears to be switching from resource scarcity to environmental quality. This will broaden the scope of forest policy goals, means and implementation emphasizing linkages with other land-based activities. Environmental concerns will also reflect in the pattern of forest products demand. Structural changes in industry will be responses to cost pressures, increasing size of investments, trade regulation and investment risks. The analyses of property rights on conservation and production are inconclusive but the promotion of private forestry appears inevitable. Efficiency calls for correcting prices and careful design of incentives. Striking an appropriate balance between economic development and environmental conservation through policies which can make *short-term private interest to coincide with long-term national goals is the key challenge of future forest policy design.

INTRODUCTION

The objective of the paper is to identify social, economic and environmental trends which will have an impact on forestry development and thereby future policy design. A problem analysis is attempted where spatial aspects are considered.

SUSTAINABILITY: FOREST RESIDURCES IN DEVELOPMENT

Sustainable development assumes utilization of resources which does not compromise the future (World...1987). The global concern on the availability of natural resources appears to be switching to the quality of environment. Striking an appropriate balance between economic development and environmental conservation is a major challenge for future policy designers.

The versatile role of forests as a renewable natural resource in development represents complexities in planning. Multiple outputs, including environmental services, and changes in resource stocks and habitats need be explicitly addressed. Earlier constraints have become part of the objective function itself. Sectoral goals should also consider other than production aspects.

If the problem of deforestation in developing countries is to be solved, forestry cannot be considered in isolation from population growth and policies related to other sectors. The Tropical Forestry Action Plan (TFAP) approach is an example of broad-based efforts where intersectoral linkages are emphasized but further analytical work is needed to deal with them in an operational manner.

Sustainability is a matter of time preference. Poverty is bound to short term deriving from the difficult survival conditions. Underlying structural problems (land pressure, overstocking, access to resources, etc.) need be addressed to halt the common process of land resource degradation.

FOREST POLICY AND ENVIRONMENTAL CONSERVATION

The role of tree growing in environmental conservation is related to maintenance of soil fertility, water catchment and habitats. These must often be considered non-renewable as regeneration of natural ecosystems cannot be brought about and restoring of large degraded areas tends to be too costly to allow investment. Trees and shrubs are often indispensable for sustainable agriculture and therefore forest policy should consider them also outside forests and woodlands, e.g. in crop fields, pasture lands, etc. Agriculture, livestock, forestry and other land-related policies should be compatible with each other.

In the industrialized countries the key problem is to seek measures to curb atmospheric pollution which is endangering forest conservation. Amenity values have become critical, especially in high population density areas. Such management interventions as clearfelling, harvesting of remaining "virgin" forests, drainage of peatlands, use of fertilizers, etc. may be considered undesirable. While the agrarian societies have evolved into industrial and post-industrial ones, fewer and fewer people live with and from the nature. This alineation tends to mystify the man-nature relationship where resource use (logging, hunting, etc.) is considered undesirable based on emotional grounds while the dependence on forest products and services is not adequately recognized. Changing values are part of structural change.

The global concern on climatic change and the resulting rise in world temperature is calling for a massive reforestation programme to complement measures to reduce emissions. Possible risks are too high to justify complacency or evasion and action will have to be taken based on qualified guesstimates. The design of such programmes should recognize that it is not only a matter of planting of trees which have a certain capacity to fix carbon-dioxide but also of establishing a resource which has to be subsequently managed and utilized in a sustainable manner.

There is a need to revise national accounting systems to reflect environmental damage and expenditure incurred by pollution abatement. A separate set of resource accounts along the practices applied in France and Norway will be needed (Ahmad et al. 1989). As long as knowledge on the costs of forest damage remain vague, remedial action will be difficult to justify by policy-makers (cf. Wicke 1989).

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DEMAND FOR FOREST PRODUCTS AND PRODUCTIVE INVESTMENT

Growing population and income have reflected in everlasting growth in forest products consumption. The pattern changes over time, fuelwood giving way to consumption of industrial forest products. During the last two decades sectoral planning in developing countries was guided by the observation of woodfuel scarcities (FAO 1981). Subsequent action to increase supplies through plantations appears to have failed in many countries which should caution about analyses relying on apparent demand-supply balances. Sociological studies should establish how people perceive their problems and possible solutions to design appropriate measures rather than offering blueprint packages.

As a result of high income elasticity at low income brackets, demand for forest products is expected to grow in developing and socialist countries faster than in the industrialized market economies. In view of increasing cost pressures strong incentives will persist to improve utilization efficiency and to encourage substitution. The development of information technology has so far increased paper consumption but its saving effects remain to be realized.

Environmental concerns are expected to reflect in demand patterns. Pressures have been mounting against tropical timber trade. Controls are likely to be introduced to safeguard that traded products originate from sustainably managed forests. Recovery of waste paper will be further increased aided by technological development allowing a wider range of uses in paper-making.

Growing size of industrial investment has increased capital deepening in pulp and paper industry. Tighter environmental standards will accelerate scrapping down obsolete capacity, particularly in Eastern Europe. The market for traditional bulk products is gradually differentiating as a result of technical change and cost pressures in user industries. The resulting restructuring will be characterized by mergers and acquisitions both horizontally and vertically across boundaries, including the developing countries. coupled with trends towards trade liberalization and economic integration, the production structure is shifting towards oligopolistic supply. When forest industries are becoming more multi-national, cost pressures are likely to increase affecting the competitiveness of traditional supplier countries. future production growth should be controlled where an increased demand for roundwood can be matched with a simultaneous strengthening of supply. Policy need be directed towards supply shifters rather than employing price policy alone (Riihinen & Tikkanen 1985).

As risks and barriers are gradually reduced future investment will be increasingly allocated in view of delivered costs and resource endowments (including conditions for plantation establishment). In labour intensive wood products the developing countries are rapidly moving towards emphasis on further processed products but sometimes in an uncontrolled manner.

PROPERTY RIGHTS AND FOREST OWNERSHIP

The natural resources which tend to be most easily degraded are those where ownership is common or in doubt. Population pressure is disrupting the sustainable management of land resources by traditional societies, The "tragedy of the commons" (Harding 1968) is experienced in depleting forests on communally owned or "public" lands under the state control but utilized by local people under customary rights. Conservation and investment are difficult to encourage if land or tree tenure is not secured (Fortman & Bruce 1968). Little systematic research available on the impact of ownership on production or conservation. The underlying assumption on better management may not be true if supplementary policy measures are not applied. Privatization does not necessarily lead to environmental conservation.

The failure of collective state ownership in the socialist countries and environmental degradation in developing countries are likely to encourage the promotion of private forestry. People's access to resources is likely to be facilitated through tenurial arrangements. Sustainable development has to address the needs of landless people which in many developing countries represent a majority of rural population. The fundamental problem is how the government can succeed in making short-term private interests coincide with the long-term national interest within a flexible and operational framework.

Increasing number of forest owners is coupled with the declining average size of holding. In industrialized countries this trend is due to inheritance and rural exodus. Urban forest owners have their own priorities and require specific policy measures (Jarvelainen 1988).

NEED FOR EFFICIENCY

Inefficiency in forest resource management appears either In unwarranted costs of production (incl. regeneration) or in unnecessary burden on environment. Two types of sources of inefficiency have been suggested (Pearce 1989). Market failure occurs if prices do not reflect the full value of forest resources ignoring environmental and user costs. Incentive schemes have often contributed to price distortions creating adverse externalities reflecting in forest degradation (e.g. Repetto 1988; Binswanger 1989). Government failures are assumed to be due to inadequate attention given to economic factors in decision-making and lack or distortion of incentives for efficient allocation of resources (Sedjo 1989). Future policy design should minimize the impact of these failures. Appraisal should reflect shadow prices of both the economy and the environment. The relationship between the desirable economic rent and the actual stumpage will remain a key issue.

The search for efficiency is gradually reducing agricultural subsidies in industrialized countries. Considerable areas of inefficiently utilized land will become available for other purposes, e.g. forestry, if a broad-based assessment can demonstrate its viability.

Several trends suggest increasing real costs of forest production (realistic economic rent, smaller holdings, environmental pressures, etc.). Labour shortages are fostering mechanization which tends to conflict with environmental costs. These pressures can to some extent be cancelled by productivity increase which should be assessed over all the factors of production.

Structural changes tend to reflect in increasing opportunity cost of capital in forestry. On the other hand, the promotion of private forestry requires that it is an economic option. In developing countries returns should furthermore be short run and production system should be adjusted to resource endowments (land, labour). It has been shown that even in marginal semiarid lands viable extensive production systems can be developed (e.g. in Australia).

CONCLUSIONS

Forest policy is likely to need a broader natural resource perspective than in the past. Forest economics will have to increasingly consider environmental aspects and unpriced values. The traditional concept of sustained-yield management should be broadened. Changing values will reflect in new policy goals beyond production aspects. Economic argumentation on policy impacts will remain necessary. Future complexities require refined policy instruments. Many countries have appropriate forest policies but they often remain ineffective due to lack of implementation. Systematic analysis of policy implementation is still in its infancy. The case of Finland shows that conservation objectives can be successfully combined with progressive forestry development in a flexible policy framework but continuous adjustment to structural changes is necessary, particularly in goal setting and implementation.

LITERATURE CITED

Ahmad, Y.J., S. El Serafy and E. Lutz (eds.), 1989: Environmental Accounting for Sustainable Development. World Bank. Washington, D.C.

Pinswanger, H.P., 1989: Brazilian Policies that Encourage Deforestation in the Amazon. Environmental Department Working Paper. World Bank. Washington D.C.

PAO, 1981; Map of the Fuelwood Situation in the Developing Countries. Rome.

Fortman, L. and J.W. Bruce, 1988: Whose Trees? Proprietary Dimensions of Forestry. Westwick Press.

Harding, G., 1978: "The Tragedy of Commons". Science 162; 1243-1248.

Jarvelainen, V.P., 1988: Factors Affecting the Use of Allowable Cut in Western and Eastern Parts of Finland. Folia Forestalia 707.

Pearce, D., 1989: An Economic Perspective on Sustainable Development. Development 1989: 2/3; 17-20.

Repetto, R., 1988: The Forest for the Trees. World Resources Institute. Washington, D.C.

Riihinen, P. and I. Tikkanen, 1985: Dynamic Forest Policy: a Key to Controlled Expansion of Forestry and Forest Industries. University of Helsinki, Department of Social Econo*mics of Forestry.

Seajol R., 1989: Forest Resource Management and the Environment: The Role of Economic incentives. in Renewable Natural Resources, Economic incentives for Improved Management pp. 76-94. OECD. Paris.

Wicke, L., 1989: Umweltokonomie. Verlag Vahlen. Munchen.

World Commission on Environment and Development, 1987: Our Common Future. Oxford University Press.

Voluntary Paper Summaries
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Zusammenfassungen der unaufgefordert vorgelegten Beiträge
Resúmenes de Ponencias presentadas voluntariamente

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SUBSTITUTION AND THE DEMAND FOR SAWNWOOD IN SWEDEN

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ABSTRACT

FDC: 721.1: 832.181: 718: (485)

Substitution and demand for sawnwood within end-use sectors are analysed. In the substitution analysis the main hypothesis is that relative prices of sawnwood and competing materials are the most important factors explaining substitution. In the applications logit models of market shares are used. It is found that the causes of substitution are not uniform over the end-uses. The price effects are smaller than expected and instead inertia seems to be an important factor.

A traditional approach is also applied for the end-use sectors where the level of consumption in the sector is regressed against explanatory factors in a direct way using dynamic and log-linear models. The total demand for sawnwood and competing products in the end-uses depends mainly on macroeconomic factors such as private consumption, gross fixed capital formation in construction etc.

In forecasting, the estimated model system has been used together with some scenarios to give tendencies for the future. The basic scenario is the long-term outlook for the Swedish economy published by the government department of finance. Additional to this scenario, time series projections on exogenous variables are used to give alternative projections on market shares and volumes of sawnwood consumption. The forecasts obtained for total sawnwood consumption in Sweden are compared to other forecasts and the main conclusion is that the forecast figures obtained in this project are substantially lower than for other organizations (FAO and FAO/ECE). One obvious reason is that this study has focused more on substitution than many other studies. At the same time economic end-use factors has been used to describe the development in the sectors.

L'AMENAGEMENT DES PARCOURS SOUS FORET AU MAROC: L'ENVIROFANNEMENT JURIDIQUE ET LES LIMITED TECHNIQUES

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FDC: 931: 451.1: 268.6: (64)

L'augmentation du revenu des populations rurales riveraines des forets, grace a la sylviculture, se manifeste par l'exercice des droits d'usage qui leur sont accordes par la legislation en vigueur. Parmi les principaux droits d'usage qui leur sont reconnus figure le paturage, composante fondamentale du systeme agraire. S'il y a longtemps, l'exercice de ce droit ne posait aucun probleme au convert boise, actuellement, l'utilisation "gratuite" des parcours forestiers est consideree comme l'un des principaux facteurs de degradation de ces espaces forestiers.

Souvant l'effectif animal, variant en dents de scie, tend a augmenter pour repondre au besoin de la population, tant rurale qu'urbaine. Ce qui se manifeste sur le terrain, par une lourde pression sur le convert vegetal, et risquera par la suite de conprometttre meme la perennite des espaces boises. Au niveau national, environ 60% de la population marocaine pratique l'activite d'elevage, surtout dans le monde rural et plus particulierement en zones montagneuses et avoisinantes des espaces boises et alfatiers. Devant une telle situation, les gestionnaires forestiers, conscients de la gravite du probleme, tentent a y remedier par deux actions dont l'une est d'ordre Idgislative, cherchant a reglementer l'utilisation de l'espace pour le parcours et l'autre technique, visant l'amelioration de la production fourragere des parcours et le developpement d'une telle utilisation.

mots-cles: Legislation forestiere, amenagement des parcours

ORGANIZATIONAL AND ADMINISTRATIVE CHALLENGES INVOLVING LARGE SCALE TRANSFER OF PUBLIC FORESTRY ASSETS TO THE PRIVATE SECTOR: NEW ZEALAND'S EXPERIENCE

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FDC: 921: 903: 681/682: (931)

New Zealand's recent experiences with transfers of public assets into the private sector were subject to research designed to determine why and how the transfers occurred and the subsequent results of such actions. Ramifications of the transfers were evaluated with respect to government budgets, agencies effected by the transfers, and the post-transfer performance of assets. The sale of cutting rights to the Crown Forest plantation assets was used as a case study to illustrate the effects on an industry sector of sudden and major changes in government policy. The process actually used to transfer the assets was compared with theoretical models. Administrative and organizational research needs with regard to large scale transfers of public programs to the private sector are outlined.

INVENTORY OF CARBON STORAGE AND ACCUMULATION IN U.S. FOREST ECOSYSTEMS

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FDC: 160.21: 114.26: 180--015

The average forest in the U.S. contains 150 thousand pounds of organic carbon per acre (16.8 kg/m^2). Total carbon storage in all U.S. forests is about 110 trillion pounds (50 billion metric tons), about 4 percent of all the carbon stored in the world's forests. Thirty percent of the carbon is in live trees including tree roots. Nearly 62 percent of the carbon is in the soil, 6 percent in dead organic material above the soil surface, and 2 percent in live understory vegetation.

Estimates of carbon in trees were derived from nationwide inventories of above-ground volume and biomass, with adjustments for the carbon in tree roots.

Estimates of carbon in the soil were developed using a model that relates carbon storage to temperature, precipitation, and stand age.

Estimates of the carbon stored on the forest floor and in the understory vegetation were derived from ecosystem-level studies.

In order to make accurate statements about the 70 percent of the carbon below the round, future forest inventories will have to incorporate new and difficult measurement techniques into the statistical sampling process.

L'IMPORTANCE DE LA NOUVELLE LOI FORESTIERE VALAISANNE DANS LE DEVELOPPEMENT DU DROIT FORESTIER SUISSE

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FDC: 931: (494)

Le concept fondamental de politique forestiere du droit forestier suisse actuellement en vigueur a ete elabore au tournant du siecle dernier; il y a environ cent ans. Grace au degre d'abstraction eleve de la loi federale mise en vigueur a l'epoque, il a ete possible de prendre en compte les changements reels dans l'ordonnance federale et les reglements d'execution cantonaux.

Les divergences de plus en plus importantes entre l'ancienne conception de politique forestiere et les nouvelles exigences forestieres ont ete ressenties plus fortement et plus tot en Valais que dans le reste de la Suisse et ceci en raison des conditions economiques et paysageres particulieres de ce canton. C'est pour cela que le canton du Valais a developpe dans sa nouvelle loi forestiere de 1985 un nouveau concept et l'a applique sans attendre la revision de la loi federale. Les premieres experiences sont encourageantes. La revision globale de la legislation forestiere suisse mise entretemps en route poursuit pour les points principaux les memes objectifs. Le projet presente actuellement pour une nouvelle legislation federale renforce l'opportunite de la reglementation que]e canton du Valais a mise en vigueur.

mots-cles: Legslation forestiere

A COMPUTERIZED SYSTEM FOR DISTRICT FOREST PLANNING IN KOREAN PRIVATE FORESTS

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FDC: 62: 923.4: (519)

The purpose of this paper is to illustrate the development of a computerized forest management information system including the labour requirements of silvicultural operations and cutting plans. A computerized district forest planning system based on Suzuki's long-term timber projection model is described. In Japan, a high proportion of forest owners are small-scale forest managers. Japanese studies of regional forest management beginning in 1950's, resulted in the development and adoption of Suzuki's Gentan probability model. This paper suggests a computerized system to predict the timber production using a Weibull distribution, which is thought more reasonable in the estimation of the tree life than Gamma distribution used by Suzuki. Results of a typical application of the system are discussed. Although the technique is oriented toward a specific cooperative forest in Kangweondo, the basic system concept should have a wide range of applications all over Korea.

The overall aim of the research is to produce long-term plans that are compatible with the Gentan probability model.

THE EXPERIENCE OF APPLYING FOREST SECTOR MODELS IN CANADA

by

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ABSTRACT

FDC: 903--01

There are four features of Canadian forestry that have marked recent research in and use of forest sector models. One is the extensive nature of the Canadian timber inventory. Efforts have been directed at modelling increasing marginal logging costs and in assessing the economic dimensions of the resource and how those dimensions are affected by economic changes. A second feature is the considerable importance that Canadian forestry has in the national economy. General equilibrium models have explicitly recognized the futility of modelling the forestry sector if important intersectorial linkages and feedbacks between sectorial and macroeconomic variables are ignored. The third feature is the dominance of forest products exports, and the monopoly power that Canada holds in certain markets. Thus various exercises have integrated the Canadian forestry sector with forestry sectors elsewhere in the world. The last but equally important feature is the decentralized, provincial, nature of forest management and policy, which make national models close to useless if not capturing the wide range of policies and regulations in place in different parts of the country.

MODELISATION D'UN FAISCEAU DE COURBES DE CROISSANCE EN HAUTEUR : AJUSTEMENT INSTANTANE D'UN MODELE A p PARAMETRES COMMUNS A TOUTES LES COURBES ET UN PARAMETRE LIBRE

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FDC: 522.31: 561.1--015.5

Résumé

Nous disposons de n courbes expérimentales de croissance en hauteur dominante de peuplements échantillon ; chaque courbe est obtenue à partir de l'analyse de tige de 3 arbres représentatifs des 100 plus gros par hectare. Ces courbes sont discrétisées à raison d'un point tous les 5 ans.

Pour modéliser le faisceau expérimental, nous adoptons un modèle global de la forme :

$$\text{Hauteur} = f(a_1, a_2 \ldots, a_p, b, \text{Age})$$

- . $a_1, \ldots, a_p$ sont les "paramètres communs", qui rendent compte de la forme des courbes : chacun prend une valeur unique, commune à l'ensemble des courbes
- . b est le "paramètre libre", qui peut prendre une valeur propre à chaque courbe pour rendre compte de son niveau dans le faisceau.

Le modèle est ajusté d'un seul coup à l'ensemble des points des courbes expérimentales à l'aide d'un programme de régression non linéaire, en utilisant des variables muettes auxiliaires : dans l'expression du modèle, b est remplacé par $b_1X_1 + b_2X_2 + \ldots b_nX_n$, avec $X_j = 1$ pour les points appartenant à la courbe j et $X_j = 0$ sinon. L'ajustement fournit les valeurs estimées de $a_1, \ldots a_p$ et accessoirement de $b_1, \ldots b_n$. Dans le modèle final, $a_1, \ldots a_p$ sont remplacés par leurs valeurs estimées ; b peut être utilisé comme indice de fertilité ou remplacé, si le modèle le permet par son expression en fonction d'un indice de fertilité plus habituel (hauteur à 50 ans, par exemple). Pour les trois espèces étudiées (Fagus sylvatica L., Abies alba Miller, Pinus sylvestris L.), nous avons obtenu des résultats satisfaisants avec le modèle : $H = (a_1A+b)\,(1 - \exp(-(A/a_2){}^\wedge a_3)){}^\wedge a_4 + a_5A$

Abstract : *Modelizing a set of height growth curves : fitting in one blow a model with p parameters common to all curves and one free parameter.*

We start from n experimental dominant height growth curves of even-aged sample stands for a given species in a given region ; each curve is obtained through stem-analysis on 3 trees representative of the 100 largest ones per hectare. Those curves are discretized, by one point every 5 th year.

In order to modelize the experimental set of curves, we use a global model as follows :

$$\text{Height} = f(a_1, a_2 \ldots, a_p, b, \text{Age})$$

- . $a_1, \ldots a_p$ are "common parameters", accounting for the curves' shape, each of them assuming one common value for all curves.
- . b is the "free parameter", which is allowed to assume a specific value for each curve, to account for its level in the set.

The model is fitted simultaneously to the whole set of points from experimental curves, by non-linear regression and using auxiliary dummy variables : in the model's expression, b is replaced by $b_1X_1 + b_2X_2 + \ldots b_nX_n$, where $X_j = 1$ for points belonging to curve j and $X_j = 0$ otherwise. The fitting provides estimaded values for $a_1, \ldots a_p$ and incidentally $b_1, \ldots b_n$. In the resulting model, $a_1 \ldots a_p$ are replaced by their estimaded values ; b may be used as a site index or be replaced by its expression in terms of a more usual site-index (like height at age 50) by solving explicitly for b $H_{50} = f(a_1, \ldots a_p, b, 50)$ if it is possible.

For each of three species here considered satisfactory results were obtained with the model

$$H = (a_1A+b)\,(1 - \exp(-(A/a_2){}^\wedge a_3)){}^\wedge a_4 + a_5A$$

This method, going straight to the concept of site-index, spares undue complications like fixing an a-priori site-index, harmonizing, and so on...

ACID RAIN CONTROL: POTENTIAL COMMERCIAL FORESTRY BENEFITS TO CANADA

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FDC: 425.1: 425.3: 415: 906: (71)

The overall impact of long range air pollution on Canadian forests and the efficacy of alternative pollution control programs is highly uncertain. Definitive knowledge on the subject will require extensive scientific research for some years. Meanwhile, a survey of scientific experts on air pollution/forestry impacts sheds considerable light on the "potential" effects. In the first part of the study, this information is used to derive an estimated range of forest productivity benefits for two hypothetical pollution control programs.

The results indicate that the expected productivity benefits of keeping the pollution level constant are relatively modest. In Eastern Canada, about a 2.3% increase in forest productivity over the option of "laissez-faire" is expected by the year 2014. In Western Canada, only a negligible 0.6 - 0.7% is expected. However, the benefits of a reduction in pollution levels by half are much more substantial, particularly in the East. By 2014, a 9.5% and a 13.2% increase in forest productivity is expected in the Atlantic provinces and Québec/Ontario, respectively. In the West, benefits range from a 1.4 to a 2.2% increase in forest productivity.

In the second part of the study, the productivity effects are translated into a stream of future harvests with and without pollution control. Because pollution affects growth and it takes a full rotation for a tree to grow, the impact of removing pollution will be felt after a full rotation. Under the hypothetical scenario of reducing the pollution level by half, there is a projected harvest increase greater than 10 million m^3 nation-wide. The majority of all benefits are expected to accrue to Québec and Ontario; they exceed $800 million (1983) per annum.

AN EXPERT SYSTEM TO SYSTEMATIZE FOREST MANAGEMENT
(Un sistema experto para la sistematización de la ordenación de montes)

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KEYWORDS: Forest management methods; expert systems; geographical information systems; personal computers.

FDC: 624--01

There are several forest management methods that in Spain can be known as traditional. Coming from the French and German schools, these methods are widely used though not fully understood nor correctly applied. A certain degree of systematization is necessary to help the forest managers in doing appropriately their job. To get this, a complex expert system is being developed in three stages:

1) Computerization of the different forest management methods (by areas, shelterwood compartments, etc) into different and independent personal computer programs. Data input in this stage come from a raw forest inventory.

2) Development of a shell to compile all these programs into a decision support system. This decision support system will help the user in the selection of the more correct method to apply in each case and in its application. Additional silvicultural, ecological, climatological, etc, data are taken here into consideration.

3) Integration of the decision support system with a geographical information system (GIS) into an expert system able to manage complex silviculture situations (log extraction paths, wind effect, cattle effect, etc). This phase involves also the critical revision of the traditional forest management methods. More complex considerations, political, economical, etc, are used in this stage.

The programs are meant to be "friendly" and interactive, featuring a window-based user interface and an easy editing, and requiring from the user only the normal proficiency in computer usage. From the beginning, this pack of programs may be used in extension, planning, education, and management in a wide sense.

A copy of the successive programs may be gotten by contacting the authors.

A MULTIVARIATE COMPOSITE ESTIMATOR FOR COMBINING MODEL PREDICTIONS WITH SAMPLE DATA

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FDC: 521.62--01

We present a method for combining unbiased sample data with possibly biased model predictions. We prove that the estimator dominates the sample mean under quadratic loss. When the model is unbiased, our estimator has risk slightly greater than the usual combined estimator. However, as the bias of the model increases, the risk of the usual estimator is unbounded, while the risk of our estimator is bounded by the risk of the sample mean.

An additional feature of our estimator is that the variance of the model estimate need not be specified. This is unlike the usual composite estimator, and eliminates a common problem for users.

We show how our estimator can be considered an approximation to the best linear combination of the sample data and the model predictions, allude to how it can be derived as an empirical Bayes estimator, and present a method for constructing confidence sets.

Finally, the performance of our estimator for estimating the average basal area per acre of a number of stands is compared to that of the sample mean and the usual combined estimator using real data.

NATIONAL INTEGRATED INFORMATION SYSTEM ABOUT FOREST RESOURCES: DESCRIPTION OF THE FRENCH NATIONAL FOREST INVENTORY PROJECT

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FDC: 905: 945.14: (44)

The French national forest inventory service (NFIS) has collected data for about 30 years. About 3 million trees and 300 000 field plots have been measured and used to produce detailed reports about forest resources (one report every 10 years for each of the 90 surveyed departments). Some of this information was underused and some user's requirements were not met although the basic data existed.

To improve use of the data it was decided to develop an integrated conversational information system which could be accessed from anywhere in France. This paper reports on this project.

The system uses a relational database (around 600 megabytes) on an IBM 3090 mainframe under IBM DB2 data base management system. This database contains the tree and plot measurements as well as coding information.

Personalized inventory results are obtained by executing simple interactive queries. More sophisticated results (like dynamic simulations or estimation of timber assortments) are produced by conversational programs which guide the user's choices (e.g. definition of the domain to be studied and of the hypothesis to be applied). Basic data may also be extracted and processed with statistical package (SAS/DB2 interface) for research purposes.

The whole system is under control of the Ministry of Agriculture and Forest and may be accessed locally or from a distance (inactive or PC-like terminal) through TRANSPAC network. The system may be accessed from foreign countries by using international networks.

To promote wider distribution, a telematic interactive application was also developed. It provides only simple and already published inventory results, but it may be accessed from any point in France at very low cost.

Users include private and public forest managers, policy-makers, wood industrialists (especially paper-makers), forest researchers, and forestry universities.

These possibilities are illustrated with an example.

LEGAL LIMITATIONS ON GOVERNMENTAL REGULATION OF PRIVATE FORESTRY IN THE UNITED STATES

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FDC: 923: 931: (73)

Private forest owners in the United States (U.S.) are subject to a variety of governmental regulations that restrict their land use and management options. These include measures intended to keep forest lands in forest use, insure continued forest productivity, and minimize the impacts of forest practices on air and water quality, soil fertility, endangered species, scenic beauty, and especially critical or sensitive types of ecosystems such as inland wetlands and coastal zones.

For the most part, this regulation finds its legal justification in the socalled "police power" of government. Police power may be defined as the inherent right of government to pass laws restricting the conduct of individuals and the use of their property when such is necessary to protect the health, safety, morals, and general welfare of the public. The concept of police power as it applies in the area of land use traces its origin to both the common law of private nuisance and the legal doctrine of waste. The basic objective of this paper is to provide a brief review of how the use of the police power in the United States is constrained by law. The discussion is intended to clarify both the powers of the regulators and the rights of the regulated with respect to private forest ownership.

Keywords: Private forest owners, Forest Regulations, Forest Resources utilization

UEBERWACHUNG GEFAEHRDETER WAELDER MITTELS KONTROLLSTICHPROBEN UND FERNERKUNDUNG/MONITORING ENDANGERED FORESTS BY CONTINUOUS FOREST INVENTORY AND REMOTE SENSING

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FDC: 581/585: 42/48

Die Informationen der grossraeumigen Waldschadenerhebungen genuegen fuer die Entwicklung von angepassten Waldbehandlungsstrategien auf der lokalen Eben nicht. Fuer ein grosses Nadelwaldgebirgskomplex wurde daher ein kombiniertes Verfahren entwickelt.Die Grundidee diesser Modelluntersuchung war die Verbindung von dendrometrischen Daten (Vorrat,Zuwachs) die im Rahmen der regulaeren Forstinventuraufnahmen auf permanenten SP-Flaechen gewonnen wurden (4-Ar Flaechen,Aufnahmen in 1973,1983,1988) mit grossraeumiger, flaechendeckandar Erfassung von qualitativen Daten (Schadenintasitaet, Bestabdesstruktur, Waldgrenzenverlauf, Standortsdegradationen) aus der Luft (CIP-Luftbildaufnahmen). Beide Informationsebenen wurden ueber die sogenannten Kontrolbestaende verbunden.Ads Konzept sichert alle wesentlichen Informationen (Zustand und Trend) ueber die Holzproduktion und die umweltbildenden Funktionen des Waldes. Wesentliche Vorteile sind grosse Datenmengen (Einzelbaeume, Flaechen) und die flaechenbezongenen Informationen (z.B.:Bestandeszuwachs in m^3/ha).

Die Untersuchungsergebnisse zeigen auf ein sehr unterschiedliches Verhalten von Jung- (ca 60 J.) und Altbestaenden (120-180 J.) hin. Die Jungbaeume reagieren auf Kronenschaeden rasch mit Zuwachsverlusten und sozialem Abstieg. Die Altbestaende reagieren jedoch kaum noch. Auch hohe Kronenverlichtungen (>60%) fuehren kaum zu Zuwachsverlustan. Der beobachtete Zuwachsrueckgang mit zunehmender Kronenverlichtung bei Einzelbaumen bedeutete jedoch nikcht auch ain tieferes Bastandeszuwachsniveau. Dieses war dank anderen guenstigen Bedingungen (Witterung, atmospherische N-Duengung, CO2-Anstieg) sogar um 10 % hoeher als in der vorangegangenen Periode. Allerdings wuerde ein voellig unbeschaedigter Wald noch eine ca. 10% hoehere Zuwachsleistung aufweisen.

"DEVELOPMENT OF AN EXPERT SYSTEM FOR A DECISION-MAKING IN TIMBER HARVESTING."

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ABSTRACT

FDC: 624--01

Artifical Intelligent techniques are expected to play important roles as a tool for future decision-making in forest management. We are developing FORMAG, an expert system to facilitate a decision-making process in timber harvesting. The objective of the expert system is to advise users on the types of tree species and their sizes to be felled, future stancing trees at the next rotation period, and formulate a plan for silvicultural treatments. FORMAG integrates information of forest inventory, future projection of standing trees based on a simulated growth and yield model, and rules for the decision-making process. Several criteria are used to facilitate the decision-making process such as: the length of the rotation period, species composition, the minimum future stands required, the cost of silvicultural operations and others. FORMAG is written in a combination of PROLAC and C. PROLOC provides a built-in inference engine and a method in representing knowledge which is very useful in the development of an expert system. On the other land, the language C is used in the area where heavy computations are blackboard architecture to provide a dynamic problem-solving environment. Rules in FORMAG are still in IF..THEN statement but with additional attibutes to facilite the shceduling mechanism of the control strategy. The paper discusses the current progress and future developments of FORMAC. An example of the application of FORMAG in a timber harvesting decision-making is given.

DAS DYNAMISCHE ÜBERGANGSMODELL ALS HILFSMITTEL DER PLANUNG UND BEWERTUNG

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FDC: 903--01

Forsteinrichtungstechnische und forstbetriebswirtschaftliche Gesichtspunkte treffen sich insbesondere in der Mittel- und Langfristplanung. Die Sicherstellung der Nachhaltigkeitsziele erfordert eine vorausschauende Analyse der zukünftigen (langfristigen) Betriebsentwicklung. Betriebsklassenbezogene Nachhaltsmodelle stehen dabei im Zentrum. Der Jahresplanung wird ein Rahmen vorgegeben, der eine flexible Anpassung der Betriebstätigkeit an die Marktverhältnisse und die sonstigen Gegenheiten ermöglichen soll.

Die realen Waldzustandsbedingungen werden mit dem Normalwaldmodell bzw. dessen realitätsgerecht angepaßten Unterformen (linksschiefe Altersklassenfigur, unterschiedliche Bestockungsgrade, Baumartenanteile und Bonitäten) verglichen bzw. an diese gedanklich angenähert. Anhand von Normalwaldmodellkalkulationen lassen sich Ertragsprognosen erstellen, Bewirtschaftungsalternativen analysieren (Umtriebszeit, Pflegeprogramm, Schäden etc.) und Bewertungen vornehmen. Die Übergangsphase von der aktuellen Situation in das Normal- bzw. Zielwaldmodell ist in einem eigenen Modell abzubilden und durchzurechnen. Eine Zuordnung von Geldwerten an Zustands- und Ergebnisdaten ist erforderlich, um die ökonomisch relevanten Relationen zwischen unterschiedlichen Objekten zielbezogen richtig abzubilden. Die Ergebnisse des Übergangszeitraumes sind Grundlage und Maßstab für Planbeurteilungen und Betriebs(klassen)bewertungen. "Normal"- und "Übergangs"modell zusammengefaßt liefern strategische Entscheidungsgrößen (Planalternativen und Wirkungsprognosen) und Bewertungsunterlagen (Plan- und Betriebsbewertung). Grundgedanken des Konzeptes, Formulierungs- und Anwendungsmöglichkeiten werden dargestellt und diskutiert.

THE PRACTICABILITY OF DOUBLE SAMPLES BASED ON PHOTO AND FIELD SAMPLES AS A METHOD FOR LOCAL FOREST INVENTORIES

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FDC: 581/585: 524.634

This research deals with the possibilities to use methods of double sampling as a substitute for conventional local systematic field samples.

The measurements were made in the forest district 'Hils' covering approximately 7500 ha. This area is located in the south-west of Lower Saxony (W. Germany). The forests were distinguished by mixed uneven-aged stands. Leading tree species were the norway spruce and the european beech.

The object was to estimate some of the most important variables of local forest inventories using a combined sample design with photo and field plots. In the first phase of the sample 300 systematically distributed plots were interpreted from 1:6000 scale colour infra red aerial photographs. For every plot the crown-density, the number of crowns, the photogrammetic mean height, the photogrammetic top height and the photogrammetic mean crown diameter were taken. To underline the practical orientation of this research all photo grammetric variables were surveyed using simple interpretation-technics only.

In the second phase one quarter of the 300 sample plots were chosen in a systematic way to be measured in the field. On every field plot the mean height, the mean diameter and the mean diameter in 7 meters height of the stems were measured.

For the comparison of the discussed sample methods the other field plots were also measured in the described manner.

After calculating the 'true' results for the field plots both phases were combined using the methods of multiple, linear stepwise regression analyses. A number of useful regression models could be constructed by selecting the photogrammatic values, some transformations and combinations of them as independent variables. The correlation coefficients of the fitted models laid about 0,8 to 0,9. They showed that there were strong relations between the dependent and independent variables. The estimation of the volume, the basal area and some additional variables like the mean diameter led to satisfying results. So the accuracy of the diameter estimation expressed by a standard error of less than ±5% was a very encouraging result. The prediction of the basal area and the volume were attended with higher standard errors. Considering the very low number of field plots standard errors of ±8 to ±10% were still acceptable.

The comparison between the results of double sampling and direct field sampling brought only low differences between both methods. The accuracy of estimation by field sample laid about 1 to 2% under the accuracy of the double sample. The absolute values of estimated volume and diameters differed about ±3 to ±6% between the two samples.

The calculation of the costs for the double sample showed the economically superiority of this method. Calculating a sample model which corresponds to an accuracy of ±5% for the standard error of estimations it could be demonstrated, that the direct field sample is five times as expensive as the double sample.

All together the results of this research bears out that the double sample plot basing on air photographs is a useful alternative to local field plots.

COORDINATION OF FOREST POLICIES AND PROGRAMS: EXPERIENCES OF STATE GOVERNMENTS IN THE U. S.

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FDC: 903: 932: (73)

Responsibility for planning and management of forest resources is seldom assigned to a single agency or organization. In state government, for example, such responsibility is typically delegated among a number of agencies, many of which may have only secondary or tangential responsibilities for forestry. In such situations, interorganizational coordination becomes an important element in determining the effectiveness public forest resource management.

Research was undertaken (in 1988) to determine the manner and extent to which state governments in the U.S. coordinate the development and implementation of forest policies and programs. Of particular interest was identification of specific coordinating mechanisms and an assessment of their effectiveness (e.g., boards, commissions, advisory groups, specialized task forces).

Forestry and related agencies in 50 state responded (via mail questionnaire) with information about the major agencies involved in coordination activities; the type of forest policies and programs requiring coordination; the tactics and strategies used to achieve effective coordination; perceptions of the effectiveness of various means of achieving coordination; and the consequences of employing formal coordinating mechanism such as boards, commissions and councils. In addition to the nationwide survey, case studies were undertaken in selected states to explore unique and especially promising coordinating mechanisms. Focus of the case studies was to provide more detailed documentation of the processes used to foster coordination of forest policies and programs.

ALLOMETRY AND TREE FORM

FDC: 561.1: 561.2: 181.64

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The biological concept of stem form is discussed on the basis of the allometric relation between stem diameter and tree height. According to allometric low, relative growth rate of two different parts of an organism, x and y are expected to be proportional or

$$1/y \cdot dy/dt = \beta \cdot 1/x \cdot dx/dt$$

In this study, x is the tree height and y is the stem diameter at some cross-sectional area. Relative growth coefficient β's were calculated for three species of needle-leaved trees. In three species, it became clear that the allometric relation shows two distinct phases on the basis for the form; $\beta \doteqdot 1$ within crown and $\beta < 1$ in part of the clear bole except the butt-swelling. Simulation based on the allometric relations could adequately describe process of developing stem form in environmental condition of stand. The allometlic analysis was also available for developing the crown of the needle-leaved tree.

EUROPEAN ADMINISTRATIVE STRUCTURES FOR MONITORING AND REGULATING ATMOSPHERIC POLLUTANTS: FORESTRY IMPLICATIONS

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FDC: 903: 681: 945.14

Starting in Central Europe, forest die back has been spreading to all European countries since the late 1970s. According to the status of knowledge, forest die back is mainly attributed to atmospheric pollution.

The Economic Commission of Europe (ECE), the responsible body for implementing the Convention on Long-Range Transboundry Air Pollution, developed methods and criteria for coordinated monitoring of forest die back. ECE and the European Community (EC) conduct such monitoring activities with increasing participation of countries since 1986. In Austria, forest authorities make use of three principally different types of scientific monitoring in a strategic sense.

Rising concern among the general population over human and environmental damages together with forest die back data produced by forest authorities has lead to a rising number of programmes to address atmospheric pollution. Still, among European countries, considerable differences exist in legislative environmental standards. Economic restrictions are limiting a quick implementation of environmental programs addressing atmospheric pollutants.

Contrary to widely held opinion, EC environmental policy emphasizes the improvement of air quality. This is shown by the Fourth Environmental Programme of the EC.

In addition to clean air policy, the individual countries of the EC have formulated programmes for forest extension. These instruments should moderate forest die back development and strengthen ecosystem stability.

Strategies for improving the policy monitoring of forest die back and clean air policy are suggested.

INFORMATION FLOWS TO FOREST POLICY COMMITTEES IN U. S. STATE LEGISLATIVE SYSTEMS

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FDC: 903: 932: (73)

Committees that focus on natural resources are key organizational units within U.S. state legislatures. Within such units rests responsibility for formulation and oversight of public policy concerning the organization and management of forest resources within state boundaries. Legislators on natural resources policy committees rely on a variety of information from numerous sources in different decision making situations. In this regard, committee staff perform a key role in mediating information flows between committee members and executive officials, administrative agencies, interest groups and others with a concern for the status and management of forests.

Research was undertaken to study the staff-mediated flows of forestry information to natural resource policy committees in each house (i.e., senate and assembly) of 35 state legislatures. The research focused on staff perceptions regarding different areas of forest policy in terms of committee attention, knowledge of committee members, and perceived adequacy of substantive policy information, and areas where efforts at improving existing information stocks are most warranted. Also examined were relationships among staff communication patterns with different groups active in state forest policy matters; characteristics of information flows from policy actors to staff members in terms of form, timing, and usefulness for committee decisions in different substantive policy areas; and the ability of actors in the forest policy arena to utilize information as a key input to political debate. Staff members also provided suggestions for improving the quality of information and the dynamics of information flows to committees concerned with forest policy matters at the state level of government.

HEIGHT GROWTH AND SITE INDEX CURVES FOR PSEUDOTSUGA MENZIESII (MIRB.) " FRANCO IN PORTUGAL BASED ON STEM ANALYSIS DATA

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FDC: 561.1: 541: 174.7 Pseudotsuga menziesii Franco

Pseudotsuga mensiesii (Mirb.) Franco was introduced in Portugal in the nineteen century (1545) but only in early seventies was considered to be an interesting forest species. Under this circumstance, it growth and yield patterns in this country are almost unknown.

Height growth and site index curves, which is a widely accepted index of timber productivity, were developed for *Pseudotsuga mensiesii* (Mirb.) Franco plantations, in Northern and Central Portugal.

Data was collected from 30 dominant trees located in 15 permanent research plots, scattered throughout the country, and selected for stem analysis by Tennent and Burkhart's method.

Curtis et al. (1974) construction method of height growth and site index curves was applied. Different corrections were introduced due; to the point of sectioning be considered to fall, on average, half way the annual shoots; to distortions resulting from the association of age and site quality, as well as for random fluctuations in mean site quality in the successive age intervals.

The index age considered was of 25 years, since most of the available stands are young, and also because this species may be considered a fast growing one. Site index curves ranged, at the index age, from 13 m (43 ft) to 21 m (69 ft).

The height growth curves prooved to be more precise than the site index curves. The comparison of the developed height growth curves with other curves of the game type developed by other authors, indicate that a similar pattern occurs in most of the european situations, but is rather inferior as far as the american west coast development is concerned.

These curves represents a first comprehensive attempt to model the Douglas-fir height growth and site index in Portugal, and further development is needed as long as new data become available.

NATIONAL INVENTORIES AND GLOBAL MONITORING: MAKING THE LINKS

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FDC: 905: 97

In September 1989, IUFRO Division IV and VI, in cooperation with the Food and Agricultural Organization of the United Nations, held an international conference and workshop on Global Natural Resource Monitoring and Assessments: Preparing for the 21st Century.

This paper discusses the recommendations from the workshop portion of the meeting and outlines steps nations should be considering to make Global Monitoring a reality by the 21st Century. Included are the need for standardization of terminology; improvements of information flows; increased technical support for developing countries; and opportunities for improving institutional and political relations.

RESEARCH OPPORTUNITIES INVOLVING BUDGETING AND ADMINISTRATION: A PERSPECTIVE FROM NORWAY

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FDC: 903: 681

Budgeting and administering forestry programmes can be looked upon as a political process where different political actors play important roles. Studies of the decision making process in budgeting and implementing programmes are important to understand the political position of forestry programmes. The nationwide forestry extension service in Norway is responsible for the implementation of forestry programmes. This implementation is done in cooperation with forest owners associations. Norwegian case material has been gathered to illustrate possible outcomes of more research on budgeting and administrating forestry programs. The area might be suitable for comparative studies among countries. The research would hopefully increase the knowledge about political and administrative behavior and an understanding of different attitudes towards forest policy in different countries.

ESTIMATION OF FOLIAR AND WOODY BIOMASS USING AN AIRBORNE LIDAR SYSTEM

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FDC: 524.3: 537: 585--015.5

The NASA Airborne Oceanographic Lidar was flown over forested terrain at two sites in the southeastern United States, producing a digital measurement of the canopy profile. Concurrently acquired aerial photography and aircraft inertial navigation system data permitted precise location of the laser's track on the ground. At random locations along the laser's ground track, trees were measured to generate local estimates of timber biomass and volume. These measurements were then compared to several lidar based variables using regression procedures.

While three laser pulsing rates were used in data collection, no significant effects to forest canopy profile area measurement were detected due to this factor. When the lidar variables were regressed against each biomass and volume variable no discernible difference in the data distribution was evident between the primary and secondary sites. This indicates that the relationships derived in this study may be used on sites other than those on which they were developed.

The resulting equations could be used in predicting forest biomass and timber volume at different sites with similar species composition and site conditions. The relationships studied have R-squared values ranging between 0.42 and 0.67 and root mean square error values ranging between 25 and 42 percent. Although the root mean square error level is high for predicting volume or biomass at a single point, the relationships are unbiased. Hence, any stand level estimation precision can be achieved through the employment of sufficient sampling intensity. By including dominant species information most relationships were greatly improved.

ACCEPTANCE TESTING OF EXISTING PREDICTION EQUATIONS FOR APPLICATION TO A DIFFERENT POPULATION

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FDC: 524.6--015.5

In forest inventories, equations fitted for one population frequently are considered for application to a different population. For example, a tree volume equation developed for one species may be applicable to another species. Other examples include growth models, percent decay estimation, and taper equations.

The decision on whether to use an existing fitted equation for a different population is often based on sample information collected from this population. Because collecting sample information can be very expensive and time consuming, the number of samples collected ideally should be limited to the number of samples required to make a decision.

Various techniques, decision criteria, and sampling designs for reaching a decision are examined in this paper. An example involving estimating percent decay in standing trees is used to illustrate the techniques.

DETERMINATION OF THE OPTIMUM ROTATION AGE FOR PINUS SYLVESTRIS L. REGARDING MANAGEMENT OBJECTIVES IN CENTRAL SPAIN (DETERMINACION DEL TURNO DE PINUS SYLVESTRIS EN FUNCION DE LOS OBJETIVOS DE LA GESTION EN EL CENTRO DE ESPAÑA).

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FDC: 613: 174.7 Pinus sylvestris L.

Rotation length depends upon the objectives aimed by the forest manager. In some Pinus sylvestris stands in Central Spain, current rotations lengths are not suitable from a economic poit of view. Optimum rotation lengths have been determined for each site index class based on inventories of experimental plots with different site indexes, a high number of standard trees and bole analysis bearing in mind the quantity and quality of the timber yield from each dimensional class of trees. This study allows the forest manager to determine the trend of silvicultural treatments and to decide the most suitable rotation length from a economic point of view.

SIMPLE RANDOM VERSUS PPS SUBSAMPLING IN TWO STAGE SAMPLING OF FOREST POPULATIONS WHEN ESTIMATING VOLUME

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FDC: 524.634: 524.34

When using two stage sampling in forest inventory, trees within fixed area plots may be selected with equal probability using simple random subsampling (Cochran 1977, Frayer 1979) or with probability proportional to some measure of tree size (Murchison 1984). Murchison (1984) compared these two designs with three others using Monte Carlo simulation in three mapped boreal forest stands (Ek 1969, Payandeh 1974). Two stage sampling with equal probability subsampling was more precise in forest populations showing random or uniform spatial distributions. Two stage sampling with pps subsampling was more precise in aggregated forest populations. The equal probability subsampling rule proved more cost effective in all stands. This rule may be biased when applied to forest populations (Murchison 1984, Murchison and Ek 1989).

Two stage sampling for both simple random and pps subsampling were simulated at all subsampling levels in 14 forest stands in northeastern Ontario. Within each stand, 3 or 4 randomly selected fixed area plots containing 5 to over 30 trees were sampled using stem analysis. Mature and immature, planted and naturally regenerated jack pine and black spruce stands of all spatial distribution types were represented.

Two stage sampling using pps subsampling proved to be the most consistent in most stands. Bias in the estimation of total volume per unit area was not a problem with either method except for a few stands using equal probability subsampling. Estimation of precision of volume estimates using pps subsampling required fewer trees in almost all populations than did simple random subsampling. More subsamples were required for estimates of standard error of volume estimates in younger than in older stands. Extreme aggregation within a population required higher levels of subsampling, particularly using simple random subsampling. The pps subsample selection rule proved more accurate and more precise in most of the populations.

The cost savings of using two stage sampling versus simple random sampling was substantial. In most populations, only 2 to 7 subsamples were required. The additional cost of creating a list from which to do pps subsampling was more than offset by fewer subsamples being required and better precision being achieved than for equal probability subsampling.

DEFORESTATION OR DEVELOPMENT IN THE THIRD WORLD?

Review of an ongoing research project, April 1989

Professors Matti Palo, Ari Siiridinen,
Mr. Gerardo Mery M.Sc. (For.) and Mr. Jyrki Salmi M.Sc. (For.).

Introduction

FDC: 914: 901: (213)

Matti Palo has carried out consulting work for FAO in four developing countries of Asia and Africa, Ari Siridinen has performed archeological research in several African countries, Gerardo Mery has lived, studied, and executed professional work in Chile, Jyrki Salmi has studied and worked in Mexico and he is actually working at the Forest Department of FAO as an assistant to the Coordinator of the "Tropical Forestry Action Plan". Therefore, the persons who compose the working group have been into personal contact with the problems surrounding the forest-based economic development in the Third World with its consequent deforestation, erosion and social costs.

Having executed a pilot study during 1986, it was decided to launch a major research project on the topic. The pilot study and the project have been undertaken by the Finnish Forest Research Institute. Additional financial support have been given by the Academy of Finland. The project has benefited from the discussions or correspondence with a great number of prestigious researchers

Aims

The deforestation and development analyses led to the conclusion that deforestation and forest-based socio-economic development were closely linked. This concept has also been emphasized by The World Commission on Environment and Develcpment, which stated: "Environment and development" are not separate challenges; they are inexorably linked".

The research project should contribute towards increasing our knowledge concerning the forest-based socio-economic development in general, and about its deforestation constraint in particular. Concomitant aims are to disseminate effectively the research results in order to improve the relevant control mechanisms and to contribute towards increased education and training on the topic. More specifically, the project would verify direct and indirect factors which explain the deforestation phenomenon by identified country groups and recognize critical factors of forest-based socio-economic development. Case studies of a few countries and comparative country analysis will be executed. Refined deforestation scenarios up to the year 2025 will be produced. The social costs and benefits of deforestation will be analyzed. Finally, policy analyses will focus on formulating policy programs to control deforestation.

THE DEVELOPMENT OF LEGISLATION AND POLICIES FOR COLORADO'S NATIONAL FORESTS

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FDC: 903--090.2: (788)

Until the mid-nineteenth century, Colorado's mountains were inhabited primarily by nomadic American Indians. From the 1860s, discoveries of gold and silver and other opportunities brought many immigrants. Thus, when the major mining booms ended at the close of the century, the state's population was mainly of European descent. Within a few decades, the landscapes of Colorado's mountains had changed substantially, particularly through the loss of forest cover from logging and fire. The mountains' population decreased rapidly after the mining era, subsequently fluctuating at low levels until the past three decades, when it again reached the levels of the mining era as recreation and tourism became the mainstay of the economy.

This paper traces the development of legislation and policies for the management of Colorado's mountain forests since European settlement. Throughout this period, the majority of these forests have been under the jurisdiction of the federal government, so that policies made both at the national level and within Colorado have affected their management. The evolution of policies at both national and regional levels is discussed within the framework of common-pool resources.

Keywords: Forest Legislation, Forest policy, Common-pool resources

SEARCH FOR TIMBER MARKET INFORMATION BY NONINDUSTRIAL PRIVATE FOREST LANDOWNERS: AN EMPIRICAL STUDY[a]

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SUMMARY

FDC: 923.4: 945.3: 71

While it is widely assumed that non-industrial private forest (NIPF) landowners need better information on timber markets, no studies have examined the actual extent, quality and determinants of NIPF owners' search and decisions. Drawing from the consumer behavior literature on search and decision processes, this paper proposes that because NIPF landowners are non-professional marketers, their search and decision processes as sellers may be similar to those they execute as consumers. Based on that theoretical framework, the paper presents the results of a field study of search and usage of market information by NIPF timber marketers in New York state. The study found that owners typically engage in little search and that their harvesting decisions differ greatly from professionally determined norms. The results suggest that future NIPF educational efforts should focus on three objectives including: (1) making owners more aware of the returns to better search and decisions, (2) informing owners about the availability, role and value of alternative sources; and (3) teaching owners how to use that information.

Keywords: Timber marketing, information search, NIPF owners, market reporting.

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[a] A considerably more extensive report on this research was published as: Rosen, B. N., Kaiser, H. F., and M. Baldeck, 1989: Nonindustrial Private Forest Landowners as Timber Marketers: A Field Study of Search for Market Information and Decision Quality, Forest Science, Vol. 35, No 3., pp 732-744.

UNDERSTANDING THE EFFICIENCY OF MODEL-DEPENDENT PROCEDURE WITH THE WEIGHTED REGRESSION ESTIMATOR IN TIMBER SALE AND UPDATING SURVEYS

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FDC: 524.63

Eight sampling strategies using the weighted regression estimator are studied to understand why one sampling design may be more efficient than another.

The results show that there is no easy explanation. A design that minimizes part of the expected mean square error is very inefficient in another part of the expected mean square error. For example, psR is respectively the least and most efficient on the two parts of the expected mean square error but least efficient overall. The extremes method is most efficient on one part, average on the other, and clearly best overall in terms of expected mean square error.

Although a clear understanding is still lacking into why one method is more efficient than another one, this exercise has been quite fruitful in suggesting promising new sampling designs.

LEGISLATION AND LAND USE CHANGE: LAND CLEARANCE AND FIELD AFFORESTATION POLICY CONTRADICTIONS IN FINLAND

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FDC: 913: (471.1)

Legislation to encourage the reservation and afforestation of agricultural land was introduced in Finland in 1969. The aim was to reduce agricultural production and rationalize farm structure at a time when two decades of agricultural progress had brought about considerable over production of certain agricultural goods. At the same time, Finnish forest industries had expanded considerably and were facing raw material constraints. Field afforestation was seen as a contribution to improving roundwood supply in the future.

A traditional element of agricultural policy has been the expansion of agricultural land. This was particularly the case in the 1950s and 1960s following the ceding of Finnish Karelia to the Soviet Union in 1944, with the loss of 420 000 ha of fields.

Strong regional variations in both field afforestation and land clearance activities have resulted from the post-1969 land use policies. While regional variations in field afforestation have been explained by variations in regional and local variations in socioeconomic development, as well as farm typology, the apparently strong and positive correlation of areas with a high intensity of field afforestation and areas exhibiting considerable land clearing activities remains to be explained.

As a measure to reduce agricultural production and to increase the production of commercial roundwood, field afforestation cannot be considered a success. The field reservation and afforestation programme revealed the weaknesses of short-term agricultural policy-making in a sensitive socioeconomic climate, further complicated by the failure to integrate agricultural and forestry policies.

Keywords: Agricultural production regulation, Field afforstation, Finland, land clearance.

EVALUATION OF THE FOREST PLANNING ACTIVITIES OF THE U. S. NATIONAL FOREST SYSTEM

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FDC: 903: (73)

During 1988 and 1989, The Conservation Foundation and Purdue University conducted an evaluation for the USDA-Forest Service of land and resource management planning for the 191 million acre National Forest System. The Study involved convening seven regional workshops, participation by a 30-member technical review committee, and reviews of literature, laws, and other materials.

It is apparent that the expectations of forest users concerning the forest planning process vary widely and differ significanty from those of land managers. Land managers see planning as a path to sound land management; users see it as a tool for achieving their own objectives, whether for wilderness or timber production. Thus, plans become both guides for management and political statements.

Among other things, forest planning has accorded the public a strong roles in decision-making, challenged the traditional role of the professional resource manager, and raised questions about the adequacy of data and technical tools like the FORPLAN analytical model. Researchers must help National Forest managers reconcile growing and changing social, economic, and environmental needs and desires with the basic productive capability of the land.

MECHANIZED THINNING
-ECONOMIC AND BIOLOGICAL CONSEQUENCES

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ABSTRACT

FDC: 242--01

Thinning in Sweden is carried out between one and four times during the rotation period of a stand. The proportion of the total annual cut accounted for by thinning, which today stands at 25%, is growing all the time.

The main characteristics of thinning work are the volume of the average stem removed (0.10 m 3 gross vol.), the thinning weight (50 m 3 per hectare) and the area of the thinning site. Together with the increased need for thinning, it was these factors that guided the rapid advances made in thinning technology during the 1980s.

The most important feature of this development has been the established use of single-grip harvesters operating on striproads. Because of the versatility of these machines, they have quickly become a major force in forestry in Sweden and have been adopted as the base system for thinnings. Today about 50% of all thinnings are carried out using single-grip harvesters, with the result that it has been possible to cut the size of the workforce and hence the high labour costs. Today, motormanual work acccounts for only 25% of the thinning cut. Productivity in normal first-thinnings using striproad-operating single-grip harvesters is of the order of 90 - 100 trees per G 15 productive hour*, so profitability is good in thinnings today.

In future, thinnings in which the mean volume of the trees removed is less than 0.1 m 3 will account for an increased proportion of the total thinning cut, which explains the growing interest in small thinning machines. So far, the most important of these have been the stand-operating harvesters. Although these machines cannot compete with the striproad-operating machines in terms of productivity, they can still be competitive in certain conditions because of their lower hourly costs.

Half of all forest land in Sweden is privately owned. Thus, in the private sector, thinning sites are often small - on average having an area of three hectares. This means that the cost of moving machines between sites can be quite high, which accounts for the growing interest in multioperation machines. These ´combines´ both fell and extract the wood, and on sites of under four hectares are competitive compared with conventional thinning systems using a single-grip harvester and forwarder.

* G 15 hour = hour of productive time including downtime
not exceeding 15 minutes per occasion.

RESTRICTIONS OF FORESTRY AND HUNTING IN NATURE RESERVES CONTENT ANALYSIS OF DECREES ON NATURE RESERVES IN BAVARIA

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FDC: 907.13: 156.2: 931: (430)

An EDP-based conent analysis of 384 decrees on nature reserves in Bavaria within the last 50 years showed great variances in the areas concerned as well as in the amount of regulations over time. Simultaneously, there was a change of goals from securing complex large areas to protecting small structured biotopes and habitats. The increased protecting efforts in the beginning of the eighthies occured against the background of seriously diminished areas to be protected. Different restrictions were imposed on forestry and hunting by these decrees that contained prohibitions, mandatory regulations and reserves as well as saving clauses. A strict or limited prohibition of forest management currently exists within 1/3 of the regulations, but it refers only to 7.5% of the nature reserves; within 2/3 of all regulations i.e. on 92.5% of the area restricted or full forestry and hunting use was allowed. According to tendency these privileges were more confined over time. Primarily, timber removals and silvicultural practices were affected by prohibitions, but even the saving clauses led to essential restrictions of forestry by area and management. Hunting was much less regulated within the nature preserves. Basically, the regulations should promote a sound and nature oriented forest management and hunting practice in the reserves. The landuse restrictions have not yet resulted in expropriations that must be compensated. Problems arise from unpriced statements in the decrees and from the unclarified relations between nature protection, forestry and hunting in the reserves. Increasing effectiveness and efficiency of the regulations could be achieved by giving priority to nature protection in the reserves, by developing more detailed protective conceptions with regard to forestry and hunting, and, at the same time by compensating forest owners and hunters for their economic losses.

Keywords: Nature conservation regulations, nature reserves

Poster Abstracts
Résumés d'affiches
Kurzreferate füt Postersitzungen
Descripción resumida de posters

Poster abstracts have been arranged in alphabetical order of authors' names.
Les résumés d'affiches ont été disposés par ordre alphabétique des noms d'auteurs.
Die Kurzreferate für Postersitzungen sind in alphabetischer Reihenfolge der Autoren aufgeführt.
Descripción resumida de posters dispuestos por orden alfabético de los nombres de los autores.

401 EVALUATION OF THE BENCHMARK FORCYTE-11 ECOSYSTEM SIMULATION MODEL

M.J. Apps, Forestry Canada, Northwest Region, Edmonton, Alberta, Canada.

A technical and scientific evaluation of the benchmark FORCYTE-11 forest ecosystem and management simulation model is being performed by Forestry Canada. The structure of the model, its theoretical basis, and the modelling approach used have been critically examined. This assessment is based on an analysis of the model's source code, a review of it's documentation, and through a series of specially designed simulation experiments. Sensitivity analysis techniques using the PROBE software developed by Apps, Kurz and MacIsaac, have been used to examine the data requirements of the model as well as its response to various resource management "gaming" scenarios.

The practical applicability of FORCYTE-11 to real-world forest management problems has also been examined in a series of regional Forestry Canada studies in Newfoundland (Meades and Pike), Alberta (Grewal, Apps, and MacIsaac) and B.C. (Trofymow and Sachs). With the completion of the benchmark model and publication of the documentation, limited use of the model by other agencies (provincial and international) and the industrial forest sector has also begun. Activities of this FORCYTE-11 user's community are summarised together with an assessment of the main strengths and weaknesses of the model which have been reported by these users.

402 THE DECLINE OF RADIAL GROWTH IN SPRUCE TREES IN ALGONQUIN DISTRICT, ONTARIO, CANADA

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Ministry of Natural Resources
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Tree-annual ring measurements on increment cores collected from red spruce (Picea rubens Sarg.) and other forest trees showed general growth decrease in eastern North America in the 1960s. This decrease in growth trend has become a major concern since this was also the period during which there had been an increase in air pollution and other climatic changes with a possible relationship to declining spruces and other forest trees. There was a need, therefore, to determine if the spruce species in Ontario are also showing similar trends.

Spruce trees are very useful as monitors of forest health and productivity in Ontario. This is illustrated by the long-term growth patterns of spruce trees. These growth patterns were inferred from the analysis of increment measurements (cores and disks) of trees that came from several forest areas. These areas have enjoyed long-term health, yet are now within the area under potential influence of atmospheric deposition and other forms of pollution. The long-term climatic changes were also investigated for correlations with growth changes.

403 GRYD-A GROWTH AND YIELD DATABASE

Sandra Barrreto, and Margarida Tome (Graduate Student and Assistant Professor, Department of Forestry, Instituto Superior de Agronomia, Universidade Tecnica de Liaboa, Tapada da Ajuda, 1399 Lisboa Codex, Portugal

The purpose underlying the elaboration of this database is twofolded: on one side the uniformization of the information available (permanent plots, temporary plots and national inventories) on *Pinus pinaster*; on the other to build a userfriendly software that permits quick access to that information, making it available for further use in growth and yield modelling.

The static structure of the database consists of three types of files: (1) *raw data files*, with the information of each reamesurent that is submitted to validation before being added to the database, these files are stored on tape after actualization of the database; (2) *primary files*, the basic files of the database, direct access files containing plot characterization (*.PAR), stand information (*.POV) at each remeasurement and tree information (*.ARV) at each remeasurement; (3) *secondary files*, build from the primary files for further use.

The dynamic structure of the database consists of three types of routines: (1) validation; (2) actualizaion; (3) access (consulting the database and building secondary files).

404 Multivariate Classification Procedures Applied to Hardwood Grade Distribution Data

by

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and
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Mississippi Agricultural and Forestry Experiment Station
Mississippi State University

ABSTRACT. Multivariate statistical procedures were used to classify hardwoods in bottomland red oak-sweetgum stands in Mississippi with regard to their probable maximum log grade. Trees were classified as follows: CLASS 1, tree contains at least one factory grade 1 log; CLASS 2, tree contains at least one grade 2, but no grade one, logs; CLASS 3, tree contains at least one grade 3, but no grade 1 or 2, logs; CLASS 4, tree contains only tie and timber material. U.S. Forest Service specifications for log grade were used throughout. Within each class, a system of volume equations was developed to predict the proportion of total tree volume by grade. These prediction equations were then used in conjunction with existing variable density yield tables to provide estimates of stand yield by grade.

405 CARIBBEAN PINE YIELD TABLES DERIVED FROM TEMPORARY SAMPLE PLOT DATA

by

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Caribbean Pine Plantation Yields

The need for yield tables in forest management is reviewed with special reference to the linear programming type of management models developed over the last two decades. When information needs for planning and prescription are immediate, yield tables derived from one-time measurements on temporary sample plots perform satisfactorily as an interim measure until those based on long-term remeasurement data from permanent sample plots become available. Temporary sample plot data from the *Pinus caribaea* var. *hondurensis* (Morelet) plantations in Sri Lanka are used as an example to derive prediction equations for dominant height, basal area per acre, and volume per acre, together with a system for site index classification. Construction of the yield equations require tree volume equations, made from felled sample trees, for total and merchantable volumes. Tree taper functions are derived from the volume equations. Two types of yield tables are derived: stand yield tables and diameter distribution yield tables. Some typical problems encountered in yield table construction from temporary sample plot data are discussed. The expected yields from the prediction equations are compared with the growth and yields of *Pinus caribaea* plantations in other tropical locations. It is concluded that the yield equations presented here perform adequately for yield estimation, financial feasibility studies, and planning future afforestation.

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406 FORESTRY ADMINISTRATION UNDER AUSTERITY AND FISCAL STRESS: MEXICO'S EXPERIENCE

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Secretaria de Agricultura y Recursos Hidraulics
Mexico, D.F. Mexico

In 1982, Mexico started facing the most severe economic crisis in recent decades. As a result, public administration was reorganized, seeking for less budgeting but trying to maintain efficiency. Forestry was merged with agriculture and animal husbandry in both administration and research. This brought advantages and limitation. These actions have resulted in experiences that can serve as a guide to developing nations experiencing financial stress similar to conditions in Mexico.

407 GROWTH CHANGES IN DAMAGED NORWAY SPRUCE STANDS UNDER THE IMPACT OF AIR POLLUTION IN SLOVENIA

Ferlin, F. (Biotechnical Faculty, Forestry, Ljubljana, Yugoslavia)

In the northern, mountain region of Slovenia (NW Yugoslavia) Norway spruce forests are predominant. Because of air pollution Norway spruce is after silver fir the second most endangered forest tree species. Research was carried out in the narrow and wide imission areas of the greatest thermal power plant in Slovenia (Šoštanj, 745 MW), build in 1985. The impact of polutted air (mostly SO$_2$) on the growth and productivity of mature Norway spruce stands (Picea abies (L.) Karst.) was investigated. The pollution was increasing until 1983. More severe damages of spruce stands appeared in 1985 on larger areas.

Severely, moderately and slightly damaged mature spruce stands were chosen at random on similar growing sites (acid soil, 1100 mm precipitation, mean temperature 6-7 °C, 850-1150 m above s.l.). The structure and dynamics of the stands were analysed in 15 research plots, size 30 X 30 m. One or two cores were taken from all the Pardey's dominant trees (about 150 trees).

Relative ring width series of the past 30 years of severely and moderately damaged stands show great sensitivity of spruce to imission stresses. 3 to 5 year abrupt growth changes appear 15 years before any visible signs of injury. Growth depressions are always followed by recovery, while the relative trends of ring widths decrease according to control stands. A very significant negative correlation (from -0.47 to -0.76) between the trends of relative growth efficiency and the relative increase of emission was proved. The stand productivity losses, expressed by mean volume increment of stands are still relatively low (to 14 %), but losses of the current volume increment of the most endangered stands have alredy become high (to 46 %).

408 USING FORCYTE-11 TO EXAMINE THE MEDIUM- AND LONG-TERM EFFECTS OF MIXEDWOOD MANAGEMENT IN WESTERN CANADA.

H. Grewal, M.J. Apps (Forestry Canada, North West Region, Edmonton, Alberta, Canada) and D.A. MacIsaac (Contractor, Edmonton, Alberta, Canada).

Increased commercial use of boreal forest hardwoods has intensified interest in mixedwood management of white spruce (*Picea glauca* Moench [Voss]) and trembling aspen (*Populus tremuloides* Michx.) in western Canada. New silvicultural prescriptions and harvest regimes for these two species must be examined for the medium- and long-term sustainability of yield and changes in site quality. Traditional growth and yield models based on data from unmanaged stands may be inadequate for predicting and comparing the outcomes of the new management options; models which include some process simulation are better suited to this task. The FORCYTE-11 ecosystem model (developed under contract for Forestry Canada) uses empirical data combined with process simulation to predict the ecological and economic consequences of a range of forest management practices. An aspen-white spruce, three-site (poor, medium and rich) calibration dataset has been developed using literature, inventory and other field data. This data set is being used with the benchmark version of FORCYTE-11 to explore the medium- and long-term impacts of intensive harvesting and utilization levels of both species in the boreal mixedwood region of Alberta.

409 OPTIMAL INTERPOLATION OF MONTHLY TEMPERATURE USING VARIOGRAM MODELING AND KRIGING

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Estimates of climatic variables, both spatially and temporally, over regions will be needed if we are to adequately address the global warming question. A new goestatistical technique, kriging, can be used to interpolate spatially dependent variables.

Following a short review of the methodology, kriging will be applied to the estimation of monthly temperature records in northern Minnesota. The data base is the 1900-82 records at 12 weather stations and 1950-82 records at 8 additional stations. Initially kriging was applied directly to the temperature values, but peripheral stations did not show similar spatial behavior with the central stations.

A structural analysis of the temperature values revealed a systematic component to the variation, changing by month, which was estimated by a linear function of the latitude and the longitude. Further analysis revealed a lake effect (due to Lake Superior) varying in strength and sign by month. A detrending approach was tested to remove these effects before final kriging was undertaken.

The steps involved in calculation of experimental variograms and variogram modeling will be described. Variogram models were evaluated for the presence of anisotropies. The cross validation technique was used to test the validity of the variogram model.

410 CURRENT STATE OF DEFORESTATION, DEGRADATION IN HOKKAIDO AND HOW TO CONSERVE THE FOREST AREA

Ishii, Y., (Hokkaido University, Sapporo, Japan)

The deforestation in the developing countries has drawn public concern all the world. Even in the some developed countries the deforestation and degradation of the forests are still going on and have created regional environmental troubles there. The purpose of this presentation is to clarify empirically the causes and extent of the deforestation and degradation of the forests in Hokkaido, Japan. Research shows that forested land has been cleared for cropping and pasture and the increaseing land demands for urban uses such as residence, highway and resort has caused forest decline as a consequence of urbanization. Furthermore it is worthy of note that the extent of degradation is larger than that of deforestation. It derives from human activities such as repeated selective cutting, deficiency of planting, due to attacks by diseases. How to conserve the forest area is presented according to the result of research.

411 DEVELOPMENT PROCESS OF FORESTRY IN HOKKAIDO

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This paper traces briefly the development process of forestry in Hokkaido after the Meiji Restoration (1868). Paying attention to the importance of regional structure in Japanese forestry, the author carried out the provable studies on the development process of forestry in Hokkaido[1]. Judging from the character of forestry structure, the time span between the Meiji Restoration (1868) and 1973 was divided into five periods. The author took up all economical organizations being in charge of the forest production at each period and analyzed mutual relations between them. To understand the forestry in Hokkaido, the paper touched firstly upon its present circumstance.

412 SEASONAL SHOOT GROWTH OF PLANTED RED PINE PREDICTED FROM AIR TEMPERATURE DEGREE DAYS AND SOIL WATER TENSION

Jones, E. A., and Reed, D. D. (Instructor, Department of Mathematical Sciences, and Associate Professor, School of Forestry and Wood Products, Michigan Technological University, Houghton, MI 49931)

The timing or pattern of growth of a species is important to forest managers when considering silvicultural treatments. On-site, rather than regional, climatic measurements were used to model red pine (*Pinus resinosa* Ait.) shoot elongation. Three study sites consisting of three 0.2 hectare plots were cleared and planted to red pine. Shoot growth was measured weekly for three years. Incremental seasonal growth of the leading shoot was estimated using a difference form of a modified Chapman Richards growth function. Weekly growth was estimated as a function of air temperature degree days (4.4° C basis), soil water tension, and total seasonal growth. The use of these variables explained the differences ($p=.05$) in shoot growth observed among the three study areas and between the 1986 and 1987 growing seasons.

413 FORESTRY TRAINING IN SOUTH AFRICA

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In this country, training in forestry was started as early as 1906 an has developed and improved continuously along with the industry since then. The process was sustained and fuelled by a drive for self-sufficiency along with a very small area of natural forests present in the country. Several other factors played a role in this regard. Provision is made for training at the professional, technical and grass root level for the main different sub-directions as required. Ample provision is made for post-graduate training.

The future of forestry in this country looks very positive and training will have to keep pace. The three main actors in the training environment are the training institution, the industry and the student. The requirements of all three must be satisfied as far as possible to ensure success. Training is a vital link in the development process of the industry and must be recognized and supported as such. Training institutions must, however, also recognize their responsibility, especially with regard to the dissemination of information and technology transfer. A much closer cooperation between the industry and the educational institution is a prerequisite in this regard.

In training a sound foundation for the future development of foresters must be laid down because efficiency and effectiveness is the key to future prosperity and survival of not only the student, but also of the industry. An integrated cooperative approach between the three parties is therefore of vital importance.

414 DOUGLAS-FIR GROWTH AND YIELD RESEARCH STUDY IN PORTUGAL

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Pseudotsuga menziesii (Mirb.) Franco is the main softwood exotic species in Portugal. Since 1970, it has been extensively used in afforestation projects, in the submontane and montane phytoclimatic levels, in North and Central Portugal. At present, its plantations covers an estimated area of 7 000 ha, and by the end of the century it is expected to triple this figure.

In 1985, a Growth and Yield research study on this species, designed to provide growth and yield information which enable an adequate management of the existing and future stands in this country, was iniciated. A set of 24 permanent research plots located in 8 stands representative of the sites where the species is growing, were installed, identified, described, characterised and intensively measured.

The stand density and stand stability were evaluated. Based on the stem analysis method, the height, diameter, basal area and volume growth, the form evolution and stem profile were studied. The site quality was determined by the Curtis *et al.* (1974) method. In general, the growth is very interesting.

The species competition model was also analysed by means of a comparative study of several competition indexes. The results indicated a better behaviour of the distance independent indexes in explaining the diameter and basal area growth, and a superiority of the dynamic criteria of competitive neighbour selection in relation to the fixed criteria.

415 CALIBRATION AND EVALUATION OF THE FORCYTE-11 MODEL FOR BALSAM FIR IN WESTERN NEWFOUNDLAND

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FORCYTE is a forest ecosystem computer simulation model developed for Forestry Canada by J.P. Kimmins and K.A. Scoullar at the University of British Columbia. We have calibrated the model for balsam fir, *Abies balsamea* (L.) Mill., in western Newfoundland using a chronosequence of six age classes across three levels of site quality. We have used the model to investigate the sustainability of growth and yield with respect to long term impact of harvesting frequency and intensity on the site nitrogen budget. Results suggest little impact of conventional (bole-only) harvest with 60 year rotation but significant decline in yield with whole-tree harvesting at 30 year intervals. However, results are highly sensitive to assumptions concerning nutrient uptake and leaching both in the models simulation of nutrient uptake and leaching and the calibration data assigned to these parameters.

416 SEMI QUANTITATIVE EVALUATION OF MULTIPLE USE FOREST STANDS

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The need for an objective evaluation of forests and forest stands in Belgium and the surrounding countries is rising, especially as a part of Environmental Impact Assessment Studies. With the presented technique a stand evaluation is given, based on 4 main stand-characteristics i.e. species composition, structure, stand prospects and impact on the direct environment. These main criteria are quoted and scaled (0-10) and used as parameters in a numerical formula that leads to a classification with 5 classes.

The quotation of the first three characteristics is obtained from subcriteria.

The quotation for tree-species is based on 5 characteristics that are inherent in the species in the Flemish part of Belgium:

adaption to climatological conditions; capacity to improve soil conditions; capacity to form the main stand; rotation age; and potential yield in optimal conditions.

The quotation for stand-structure is based on:

presence of different layers;
species composition of the main stand (mixed versus homogeneous planting); and the stocking degree of the main stand.

The quotation for stand- prospects is based on;

sanitary condition; the management; and adaption to site conditions.

Application of this evaluation method has improved the communication between interdisciplinary specialists involved in a project. The possiblity of quantifying a certain impact has proved to be very useful in the process of decision-making.

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A VARIABLE-FORM TAPER FUNCTION

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The topic of stem form and taper has been studied for over a century and is still of high priority in forest research for perhaps two reasons. First, no single theory has been developed that can explain how stems vary in form, both within and among trees. Thus it has not been possible to construct a satisfactory taper function that would be uniformly acceptable over a wide range of conditions. Second, and more important from a practical point of view, a taper function that can accurately predict the diameter at any point on the stem from one or two readily measured variables, is essential for estimating the volume of standing trees and for constructing volume tables to different merchantable limits.

The taper function described in this poster is relatively simple. The stem is considered to be a solid with a form that varies continuously from the stump to the tip. An allowance is also made for the effect on form of live crown ratio. The model has been tested on data from a red pine (*Pinus resinosa* Ait.) spacing experiment at the Petawawa National Forestry Institute and found to give accurate and unbiased estimates of stem diameter and volume.

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A SIMULTANEOUS DENSITY-INTEGRAL SYSTEM FOR STEM BIOMASS

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As early as 1950, the use of weight as a measure of wood quantity has been practiced by many of the larger companies in North America and northern Europe. The use of weight measurement has steadily grown in importance with the increased demand for wood fiber and fuel. A recent development in tree-biomass estimation procedures has been the introduction of the density-integral methodology. This technique, and alternative to weight-ratio methodology, was developed on the basis of some simple calculus of mass theory (Parresol and Thomas 1989)[1]. In the initial development of the technique, sectional bole weight was derived from the integral equation formed from a stem-profile function and a specific gravity function fitted independently. Recognizing the interdependence of the equations, and the need to incorporate observed stem-weight in the fitting process, a more efficient and consistent parameter estimation approach is available through econometric methods. A simultaneous system of three equations is identified and parameters are estimated using restricted two - and three-stage least squares.

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[1] Parresol, B.R. and C.E. Thomas. 1989. A density-integral approach to estimating stem biomass. *For. Ecol. Manage.*, 26:285-297.

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EXAMETABOLITES OF BETULA PENDULA ROTH. AS A FAKTOR, REGULATING PINUS SILVESTRIS L. GROWTH

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The widely used synthetik means of growth regulation do not always influence the environment favourably. The substances, inherent to plants attract our attention. It is known that plants secrete different substances with high enough biological activity.

Since 1982 we have been studying exametabolites' characteristics of Betula pendula Roth, the effect of Pinus silvestris' seeds and needles treatment by these substances. The enrichment of pine seeds by the extracts during a twenty-four hour period at room temperature influences the Pine's sprout germination and its further growth favourably. The control excess is without error and reaches 10-20 per cent.

The influence of exametabolites on pine seedlings growth is connected with the rise of water exchange, breathing, oxidoreductase activity, etc. The effect of soluable substances of Betula pendula Roth. is discussed.

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Relating Light Environment to Growth through Hemispherical Photographs

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Abstract: Light environment is one of the primary factors influencing tree growth. Though the relationship of this factor to growth is well understood from experiments on seedlings and saplings in controlled environments, little research has been conducted to establish this relationship in uncontrolled mature forest conditions. This pilot study establishes_the relationship of light environment to annual growth and serves as a foundation for linking physiological responses to individual tree and stand level growth models.

Horizontal hemispherical photographs were taken with a 180 degree fish-eye lens on a 3 dimensional grid and over designated sample branches in the crowns of three loblolly pine (Pinus taeda L.) trees. The measurements were taken at the beginning, middle and end of the 1989 growing season. The light environment was estimated by scanning the pictures and using a program to simulate the sun trajectories for the days of interest from the scanner file. After all photographs were taken the crowns of all trees were three-dimensionally mapped for the calculation of foliar distribution and crown dimensions. Finally each tree's crown and bole were destructively sampled to estimate growth. The preliminary results of this study, the utility of this method and future research plans are discussed.

421 SUSTAINABLE DEVELOPMENT IN TEMPERATE FORESTS: EXPERIENCE FROM PENNSYLVANIA

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Dwindling export supplies of tropical hardwoods and increasing costs due to export restrictions in producing countries have led to a shift in demand toward temperate hardwood species. Demand for U.S. hardwoods is expected to increase at a rate of 2% per year through the year 2000. The state of Pennsylvania is amply supplied with desirable hardwood species and has embarked upon a program to expand production. Supporters of Pennsylvania's Hardwood Initiative are coming to realize that long-term sustainability of forest-based economic development requires active measures to protect and enhance the resource base. Threats to sustainability come from several sources: 1. Market pressure to harvest select species at a rate in excess of replacement, effectively mining existing stands; 2. Political pressure to remove public land from commercial timber production; 3. Social pressure to view timber harvesting as deforestation; 4. Insufficient investment on private land in measures to ensure future hardwood stands of desireable species; 5. Loss of biodiversity from overgrazing by white-tailed deer; 6. Insects and diseases; 7. Other regulatory pressures that will effectively reduce the commercial land base. These issues can be cast into a series of policy questions: Will future timber supply be adequate in volume, species, and quality to sustain a profitable, vigorous primary processing industry that will be the foundation of an enlarged secondary processing industry? Will returns to landowners be sufficiently high for needed investments to manage and regenerate stands, and are there ways to educate or induce the private landowner to make needed investments? How can the wood industry change its public image and show that sustainable management of temperate forests is possible and that wood products have less total environmental costs than substitutes made from aluminum, steel, or plastic? If the economically available commercial forestland base is reduced by these pressures, can we identify the best sites, in terms of return on investment and lowest environmental cost, on which to practice more intensive management?

422 TESTING THE PERFORMANCE OF FORCYTE-11 AGAINST RESULTS FROM THINNING AND FERTILIZATION TRIALS IN DOUGLAS-FIR.

Trofymow, J.A. and Sachs, D. (Forestry Canada, Pacific Forestry Centre, Victoria, B.C.)
To establish the scientific usefulness of FORCYTE-11, an ecosystem-based, forest management simulator, its output was tested against a dataset of independent empirical results. The data were from a thinning and fertilization experiment in a 40 year old stand of *Pseudotsuga menziesii* at Shawnigan Lake, B.C. (east coast of Vancouver Island). FORCYTE-11 predictions were compared to data for 22 variables including tree numbers, mortality, DBH, total and canopy height, volume, biomass components and litterfall nitrogen and mass. Depending upon the variable, data were available for a 15 year period, stand ages 24-40 years, on a yearly or three year basis. The model was tested in two phases: In the first phase the model was run uncalibrated for the site using data sets provided by the model's authors but initialized so that stocking, stand conditions, and treatments were identical to those in the 24 year-old stand at the start of the experiment. Stand growth was simulated to 60 years. In the second phase the model was calibrated for site and stand growth conditions in control plots from 24-40 years and then rerun for the thinned and/or fertilized plots. Initial comparisons of data with the uncalibrated model showed that the model simulated growth in treated plots more accurately than in control plots and was probably due to the model's weakness in its simulation of decomposition and soil organic matter. Additional comparisons will be presented for the calibrated model. (ENFOR research project P-374).

423 EFFECTS OF SAMPLE PLOT CO-LOCATION ERRORS ON CORRELATION OF COVARIATES IN A MULTI-PHASE, RENEWABLE RESOURCES INVENTORY CONTEXT IN ALASKA

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Regression estimators for renewable resources quantities were employed by the Pacific Northwest Research Station work unit, Forest Inventory and Analysis (FIA), Anchorage, Alaska in the Tanana River Basin and the southeastern panhandle. Initial results show low correlations between most covariates from the different sampling levels. Statistical consultation indicated co-location of sample plots on various remote sensing levels and the ground may have been a major influence. This study is an examination of changes in covariate correlations resulting from plot co-location errors attributable to improper remote sensing and ground surveying procedures.

424 An Expert System for silvicultural Decision-making in the National Forest of the Republic of China

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Expert system are computer programs capable of solving
problems with the ability of human experts in specialized fields. An
expert system was developed to help foresters in selecting the right
species to be planted in each forest environment of the national for
in the Republic of China. The national forest of China is a multiple
resource management forest encompassing a wide variation in topograp
soil types, climates, vegetation types and resource demands. The
national forest should have two functions. The first function is tim
production and the second function is providing public benefit. Publ
benefit includes conservation of land, protection of the natural environment, and recreation. The selection of the right species for ea
site is quite complex because it depends primarily on human experier
and judgement. The selection's goal is to find a suitable species tr
will grow and develop to become a healthy forest. Therefore, it is
particulatly desirable if the expert system could be developed to
address this area. This expert system utilizes many forest environme
factors such as altitude, toptgraphy, air temperature, soil type anc
stand structure factors. Selection rules used in this expert system
not perfect and need to be improved. However, the expert system does
represent a major step towards the selection of the right species fc
each site in Taiwan.